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MAGNETIC SURVEY OF THE UNITED STATES.

Two important reports have been issued by the department of terrestrial magnetism of the United States Coast and Geodetic Survey, giving certain results of the careful magnetic survey which is being carried out by this department. The present reports cover the territory of the United States, and include a comparatively small area of water and of the neighboring countries. It will be remembered that important work has been done by the department in making a magnetic survey of the Pacific Ocean, which hitherto has been almost a blank. Certain of the results of these measurements made near the western coast have been available for use in the present reports.

An important feature of this survey is the large number of observation stations. Measurements have been made at about 3,500 points, and have thus given the department what is probably the most complete data that any country has dealing with this matter. The completeness of the survey is well indicated by the chart accompanying the report, which shows no resemblance to the smooth, easy curves which would be drawn between points widely separated. The lines twist and turn in a most extraordinary way, and bring out very markedly certain effects due to physiographical conditions. Thus, the lines along the coast, and particularly those along the Appalachian Mountains, are very tortuous. A discussion of this feature of the chart is promised for a subsequent report.

The report also shows the lines for equal secular change, and contains tables giving the secular changes for every state and territory, from the earliest observations, thus enabling any one to determine the declination of any previous date. These tables should be of very great value to engineers, besides being of much scientific interest.

A study of terrestrial magnetism is not only of great scientific interest, but is of considerable practical importance. The work which the department has been doing not only throws a great deal of light upon the conditions as they now are, but gives the student of this natural phenomenon something to work upon. Only by such painstaking efforts can we hope to arrive at any satisfactory explanation of the earth's magnetism. It is to be hoped that it will not be many years before a similar work is undertaken in exploring the atmosphere. At the present time our knowledge of atmospheric electricity is very small—in fact, we know very little about the air, as the observations we now depend upon for the weather predictions are limited to a few conditions, such as the wind and temperature, and are made within a very thin layer. What is going on above we can only surmise.

THE SEARCH FOR HIGH-EFFICIENCY INCANDESCENT LAMPS.

The search for methods or materials for making what are called high-efficiency incandescent lamps goes vigorously on, and each announcement of a new lamp brought more or less to a practical stage of development is followed by another relating to still another lamp. Meanwhile the various aspects of the lamp situation are being discussed by the different societies interested in the work, so that there is to-day a wider appreciation of the factors entering into the problems of making and introducing the new lamps.

Perhaps it may not be amiss to call attention to the fact that the expression "high-efficiency lamp" is correct in a limited sense only. The usual use of the term "efficiency" in engineering language is to denote a ratio of two similar physical quantities. In photometry, however, it is used to denote a ratio between two dissimilar quantities. In the ordinary sense, the efficiency or, to be specific, the energy efficiency of the new lamps is not high when compared with other electrical apparatus, though it may be two or three times better than that of the old lamp. It is high in the limited sense—that is, as expressing a ratio of energy consumed to light given out, because the performance of the new lamps is much better than that of the old. It may be questioned whether the latter use is desirable, as it is apt to lead to confusion. Moreover, since the ratio is usually given as watts per candle it is anomalous to have a higher efficiency denoted by a smaller ratio.

One interesting phase of the lamp problem was discussed in a paper read recently by Mr. James Swinburne before the Institution of Electrical Engineers of Great Britain. This paper, after touching upon certain features of the development of the carbon filament, described briefly the various methods now being tried for forming filaments from other materials, and discussed the known physical and chemical properties of a number of elements which seem to offer some possibility of making more efficient incandescent lamps. An abstract of this part of Mr. Swinburne's paper is given on another page of this issue.

Although there is not very much information available concerning a number of the elements thought to offer possibilities of an improved filament, by means of the periodic law those elements most likely to give success may be picked out. It was pointed out that those elements having a high melting point usually have small atomic volumes, and that the electrical conductivity seems to follow a similar rule. Fortunately, during the discussion of Mr. Swinburne's paper Dr. J. A. Harker was able to give a table showing the most recently determined values for the fusing points of a large number of the elements. These values, which are given in the table reproduced with Mr. Swinburne's article, show that there are only a few elements which are not fused at a temperature of 1,500 degrees centigrade. It must be remembered, however, that the fusing point does not determine whether an element will be suitable for such use, for, as was pointed out by Dr. C. P. Steinmetz in his recent paper before the American Institute of Electrical Engineers, it is more important that the vaporizing point should be high. A material which vaporizes at a comparatively low temperature is obviously unsuitable for forming filaments. It is not essential that the filament should consist of an element, as a suitable compound may be used. The carbides seem to offer the best field for experiment, but some of the carbides are insulators at low temperatures, and therefore are not suitable, since they would require a starting device. It is probable that those filaments made by depositing other materials upon carbon consist, in part at least, of carbides, as even when it is endeavored to drive off all the carbon it is likely that part, at least, will remain in combination with the other elements. In this connection it is interesting to note a remark by Dr. Harker during his discussion regarding the use of silicon. Sir Joseph Swan attempted to make filaments from carborundum, but found that above 1,900 degrees centigrade there was little affinity between the carbon and the silicon, and at 2,000 degrees the silicon distilled out and burned, leaving only the carbon behind. This statement is suggestive when taken with a description of the Helion lamp given in the issue of the ELECTRICAL REVIEW for January 19, the filaments of which were said to be formed by depositing, from their vapors, "silicon and other materials" on a carbon filament.

PROOF, NOT FAITH, NEEDED.

There is, unfortunately, often too great a tendency on the part of many of us to accept without question explanations given of physical phenomena. When the authority for the statement is given, and if this authority be good, there is reason to put some trust in it; but even then one is not likely to go wrong if he examines the phenomenon for himself and tries to see why the result should be as it is. On the other hand, when no authority is given for the explanation it should never be accepted without a critical examination. Often a pretty idea is offered which might possibly be true, but which is very unlikely. It is better, before agreeing to this, to see whether there is not some other explanation which is more probable. Of course, it is necessary in all engineering work to rely largely upon the results of the work of others, but these results should never be used unless it is known whence they came.

An example illustrating this idea of always questioning every explanation is found in a recent issue of a new journal. The story is this: An electro-plating company installed a dynamo to take the place of the batteries previously used. During the first day work went on nicely, but, in the evening, an inexperienced attendant, in his hurry to leave the shop as soon after the blowing of the whistle as possible, merely stopped the dynamo, leaving a good deal of work in the plating vats, and without opening any switches. In the morning the work was started again by starting the dynamo, but it was found that now the current was stripping the work and plating the silver electrodes, and, therefore, in some way or other, the current through the vats had been reversed.

The cause of the stripping was evident, but the question is raised, how did it happen that the current was reversed on the second day? The explanation offered is as follows: After stopping the dynamo the plating vat formed a primary battery

and sent a current in the reverse direction through the dynamo, thus reversing its polarity; consequently, on the second day what had been the positive brush became the negative, and the current through the vat was reversed. This is a possible reason for the trouble, but it hardly seems probable; in the first place, the only electromotive force available for driving the current through the dynamo was due to polarization at the electrodes in the vat, and it is hardly likely that this was sufficient to accomplish the result, since, no doubt, the dynamo was given a voltage considerably higher than that utilized in the vat, and therefore the voltage available for reversing the dynamo fields was, in all probability, too small to reverse them. Moreover, this reversal would not take place if the machine were shunt wound, and it is hardly likely that it was a simple series-wound generator. It must therefore have been a compound machine, in which case the number of series turns would be comparatively few and the ampere-turns, due to the current of polarization, would be too small to reverse the fields. It seems more likely that the inexperienced attendant reversed the connections at the vat as this was not difficult to do. Or there may have been other causes not mentioned. Such reversals of magnetization were not infrequently encountered in the early days of electric lighting and railway work, and often the cause was very hard to find. That given above may very properly be questioned and it illustrates the point, that it is always better to see whether a given explanation fits the facts, rather than to accept it unquestioned.

THE ELECTRIC FURNACE.

The electric furnace has given us a number of materials heretofore inaccessible—in fact, it has progressed faster than the mechanical industries and has made available, at moderate cost, metals and other substances which were formerly chemical curiosities, and for which there has, as yet, developed little demand. It has also made some progress in replacing older and less effective methods, and its enthusiastic supporters have frequently predicted that in a few years all our iron furnaces will be out of commission. What changes may come about in ten or fifteen years no one can say, but there is no evidence to-day indicating that the blast furnace is an antiquated device. In fact, it is highly efficient and has a large productive capacity, two features which are of very great value.

In other branches of the iron industry there are greater possibilities, such, for instance, as in the production of high-grade steel; and here the electric furnace has some advantages on its side which may more than balance certain disadvantages accompanying it. It is in such directions that the electric furnace must make its way. In fact, the situation does not differ from that in very different industries. The electric method has been adopted because, for certain particular uses, it was better than any other, and its application in this way, under average working conditions, made possible improvements and advances which led to further extension until, in some cases, it has seized almost the entire field. Electrical methods are even used where there are others in some ways better, but the objection to employing two systems in one industry must be weighed against the advantages of a certain process in one small branch. A more expensive process is justifiable for a small part of the work if it simplifies the entire equipment of the shop. It is probable that for reasons of this kind the use of the electric furnace will be extended; but as yet no work has been done which indicates a wholesale change in all metallurgical processes.

THE VIENNA LOCOMOTIVE.

In the issue of the ELECTRICAL REVIEW for February 2 a description was given of a very interesting locomotive built for the Vienna City Railway, which is well worth examination. This locomotive is equipped with direct-current motors built for comparatively low potentials, although the supply is to be at the fairly high direct-current potential of 3,000 volts. The method of bringing this about is to connect the four motors of the locomotive in series, so that the voltage of each will not be more than 750. A serious objection to connecting motors in series is the liability to slipping. One motor begins to slip its wheels, the tractive coefficient is thereby decreased so that the speed tends to increase, and as the speed increases the difference of potential across the brushes increases, so that this skidding motor is drawing excess power at the expense of the other motors. To avoid this contingency the motors are grouped in pairs, each pair being geared to one axle; therefore it is impossible for one motor of a pair to race at the expense of the other. It is still possible, however, for one pair to speed up, but as the locomotive is carried on two axles only, this is not so likely to happen. Moreover, slipping is most apt to cause trouble when starting, and the method of starting the locomotive obviates this. And furthermore, current is supplied to the locomotive by means of two overhead wires, the rails being used as the centre wire of a three-wire system, an arrangement which will prevent racing of one pair of motors. To start the locomotive the two pairs of motors are connected in series between one overhead wire and the rail, so that the voltage across them is only half of the normal. A comparatively small resistance is employed to prevent excessive acceleration. After the motors have come up to half speed in this series arrangement, one pair is cut out and thrown across the other side of the system and they are brought to full speed by again cutting out the resistances reintroduced during the transfer. By this means the benefits of a series-parallel arrangement are used without the motors really being connected in parallel. Other features of the locomotive of interest are the small auxiliary motors, which operate at the normal potential of 1,500 volts.

If this locomotive should give satisfactory results, by substituting the newer direct-current motors, which are suitable for higher voltages, a still higher supply voltage may be employed. Four 1,500-volt motors used in this way will raise the supply voltage to 6,000. By using only 3,000 volts two pairs of motors may be connected in parallel, without resorting to the three-wire system. In case of the disablement of one pair, the locomotive could get home by means of the other.

British Hydroelectric Installations.

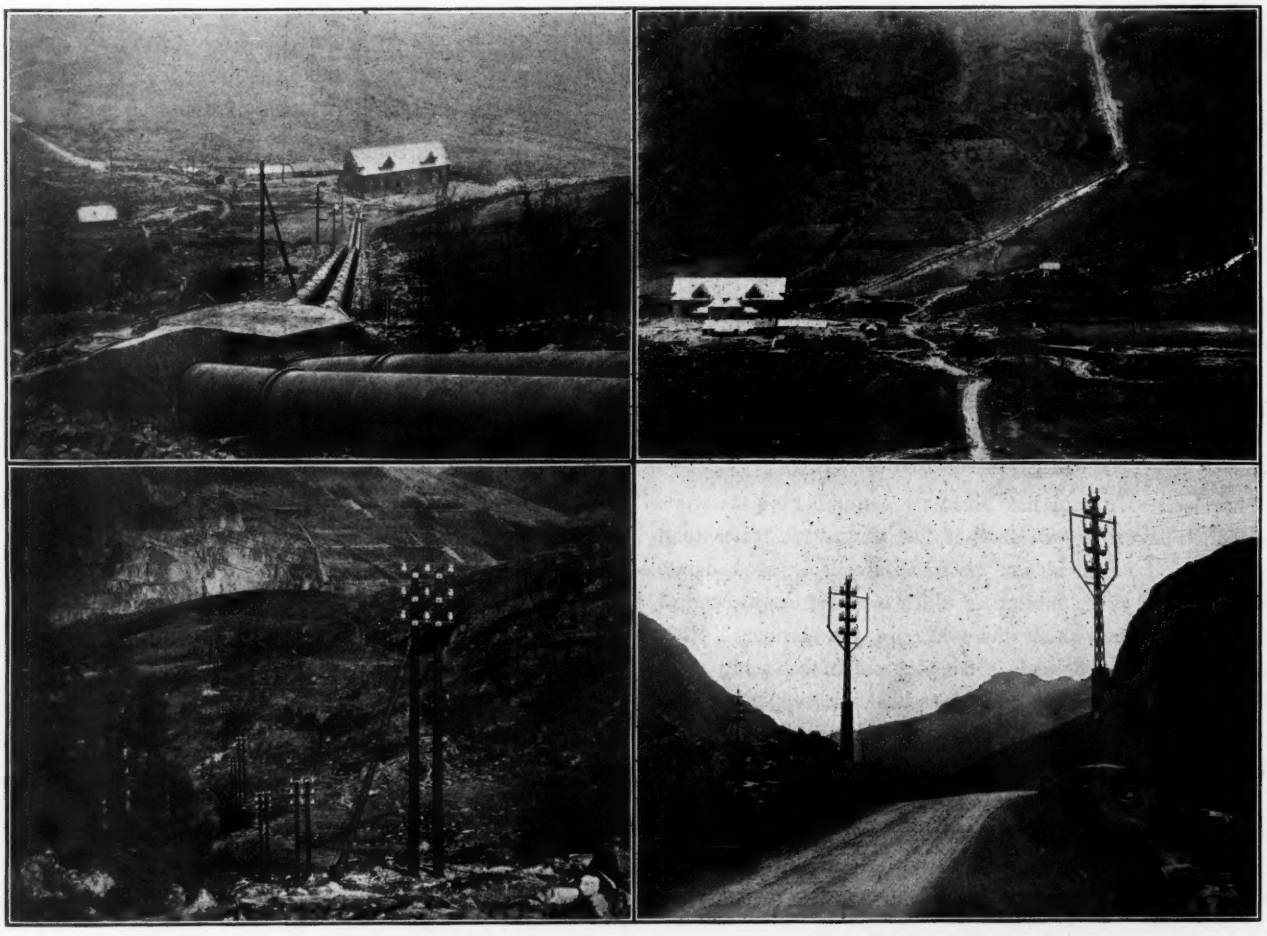
By A. H. Bridge.

THE UNDERTAKING AT LOCH LEVEN, SCOTLAND.

ONE of the principal electrical undertakings that is in the construction stage at the present time in the United Kingdom is the hydroelectric scheme of the British Aluminium Company, Limited, which is laying out more than three million dollars upon works, plant, a great dam, a four-mile conduit, workmen's buildings, etc., in Scotland, for the utilization of Loch Leven water power. It is, of course, common knowledge that the company has been utilizing the Falls of Foyers in connection with its aluminum manufacturing operations for many years, but as it became clear that the maximum that could be produced at Foyers would not meet the demand, extensions are being pushed forward at the Larne works. The completion of the Loch Leven scheme is, however, the great event toward which the company is looking, though that event is still a long way from being an accomplished fact. In the event of the demand for aluminum continuing as large as it was during 1906, it is the British Aluminium Company's intention to use the entire power available from the Loch Leven scheme for this purpose. The contract for the works is in the hands of Sir John Jackson, Limited—it was let to that firm in July, 1905, operations being commenced immediately thereafter. The great dam will be eighty feet high, 1,000 yards long, eighty feet wide at its base, and ten feet wide at the crest. It will hold up water which will form a lake of four square miles, and according to J. D. Bonner, the chairman of the company, it will contain more water than any other artificial lake in Europe. The conduit is to be four miles long, and the power station and generating equipment are being designed by Sir Alexander Kennedy, in conjunction with Mr. Morrison, the company's own engineer. If, as we have suggested, it is decided to utilize the whole available power in aluminum production, there can be produced at Loch Leven three times as much as can be turned out at the existing works at Foyers.

THE DEVELOPMENT OF LAKES GLAS LYN AND LLYN LLYDAW, NORTH WALES.

The most recently actually completed hydroelectric installation of any size in the United Kingdom is that to which some attention is at present being given in North Wales. While those who have been so unfortunate as to put money into the electric-power supply undertaking in South Wales, either as general investing shareholders or as plant or cable manufacturers who took shares in part payment for the work under the contracts, are bemoaning the financial weakness of the concern, and while the company is itself shivering on the brink of ruin, this other scheme in the North, which embodies



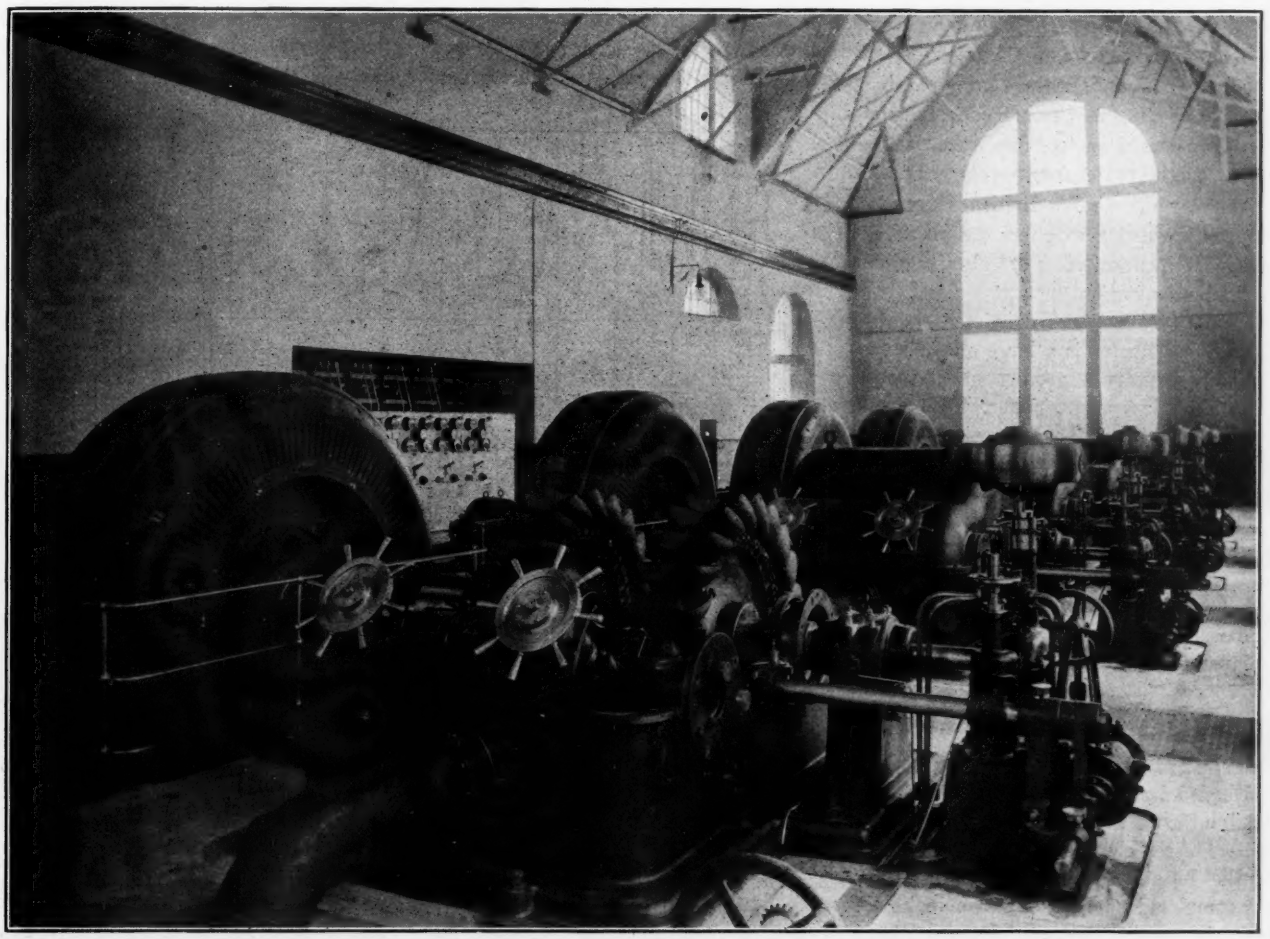
North Wales Power Company. 1.—Pipe-Line with Power-House in the Distance. 2.—Pipe-Line Leading Down to Power Station. 3.—Wooden Pole-Line Near Dinorwic Quarry. 4.—Transmission Line Across Llanberis Pass.

many very interesting features, is getting well to work. Any attempt at estimating the financial probabilities would be quite useless at the present stage, but the supply of energy is first being given to a number of quarries in the district; an electric railway now being constructed for the convenience of quarry workmen and tourists will take supply shortly, while some of the local authorities will take electricity for lighting their districts before very long.

The undertaking is owned by the North Wales Electric Power and Traction Company, Limited, for whom Harper Brothers and Sir Douglas Fox and partners have, in the capacity of consulting engineers, supervised the laying out of the various hydraulic and electrical equipment for the utilization of the 1,100-feet drop from Lakes Glas Lyn and Llyn Llydaw, which are situated about halfway up Mount Snowdon. The pipe-line is approximately a mile and a quarter in length to the power station in the valley below. The intake works consist of a tunnel of six feet diameter, which terminates in a duplicate pipe-line, as will be seen in one of the accompanying engravings. Either of the pipe-lines would be sufficient to meet the needs of the station in the event of a prolonged drought, though the latter is not expected, judging from past experience.

The power station building is about 145 feet long by forty-five feet wide by fifty feet high, and, on account of the locality, a special design of roof was put on for protection in snowy periods. From the view herewith of the interior of the station it will be seen that there are installed so far four 1,500-horse-power twin Pelton wheels, which are direct-coupled to three-phase alternators of Bruce Peebles's design and build. The Pelton wheels are of ordinary design, having steel buckets bolted on to the periphery of a turned steel disc, and having hydraulic governors to regulate the speed, which normally is 500 revolutions per minute. Each of the alternators has twelve poles, and its rated output is 1,500 kilovolt-amperes at 10,000 volts, fifty cycles. They are all of the revolving-field type supplied by Bruce Peebles & Company, Limited, of Edinburgh, Scotland, who, indeed, were the contractors for the complete undertaking. Each alternator shaft carries, on an extension, a four-pole, forty-five-volt exciter. There is a ten-ton hand crane in service in the station for repair and such purposes.

The switch gear part of the equipment is of Ferranti make and it is located in a room which opens into the station and has switch panels on two sides facing each other, the other two sides having protective wire grills. There are six machine panels, six feeder panels, two summation panels and two spares, all of white marble. Bare copper leads carried on porcelain insulators run through the basement from the generators to the oil circuit-breakers, leading thence to ring bus-bars supported by porcelain insulators on the bar-frame above. The feeder connections are taken from the opposite half of the ring, the meters being interposed between the generator and feeder sections. From the bus-bars the feeder connections pass down to the feeder oil-switches, from which the outgoing feeders are led up to the board, through choking coils, and down to a strain-frame outside the building. The power station plant and



NORTH WALES POWER COMPANY. PELTON WHEELS, DRIVING 1,500-KILOVOLT-AMPERE, 10,000-VOLT, THREE-PHASE ALTERNATORS.

the framework of the switchboard are earthed on a structure of copper sheets on a copper frame, sunk in the bed of a stream near by.

Altogether the North Wales Company has twenty-six miles of transmission lines. A three-phase line goes over the mountains to feed quarries situated at Blaneau Festiniog, some seven miles away, but another, the chief transmission, consists of three three-phase lines (nine millimetres) which run over Llanberis Pass, a six-millimetre line branching off to feed some quarries at Dinorwic; a further transmission proceeds to Penyrorsedd Quarries, at Nantlle. For the transmission lines creosoted wooden pole-work is mainly employed, but for specially severe weather conditions at the Llanberis Pass section, steel lattice poles, each stayed at four points, are used.

At every three miles British Thomson-Houston lightning arresters are provided, and lightning protectors are also installed at the power station.

In the North Wales district the slate-quarrying industry is a large one and the company expects a good power demand from this class of consumer. The present consumers are the Dinorwic quarries, taking 250 horse-power; Penyrorsedd, taking 750 horse-power, and Oakley, taking 1,900 horse-power for haulage, air compressor, sawing and trimming, pumping, and other classes of electrical service.

For the accompanying photographs the writer is indebted to Bruce Peebles & Company, Limited, the contractors.

Practical Instruction at the Iowa State College.

Headed by Professors F. A. Fish and Adolph Shane, a party consisting of fifteen seniors of the electrical engineering course of the Iowa State College, Ames, Iowa, has completed a tour of the principal electric plants and factories manufacturing electrical apparatus in Chicago and Milwaukee. The trip was timed so as to enable the students to visit the Electrical Show at Chicago. During their stay in the city the students also inspected the plants of the Commonwealth Electric Company, the Western Electric Company, the Kellogg Switchboard and Supply Company, the Automatic Telephone Company and the power plant of the Metropolitan Elevated Railroad Company. In Milwaukee the students were given an insight into up-to-date methods of manufacturing electrical apparatus at the works of the Allis-Chalmers Company and the Cutler-Hammer Manufacturing Company.

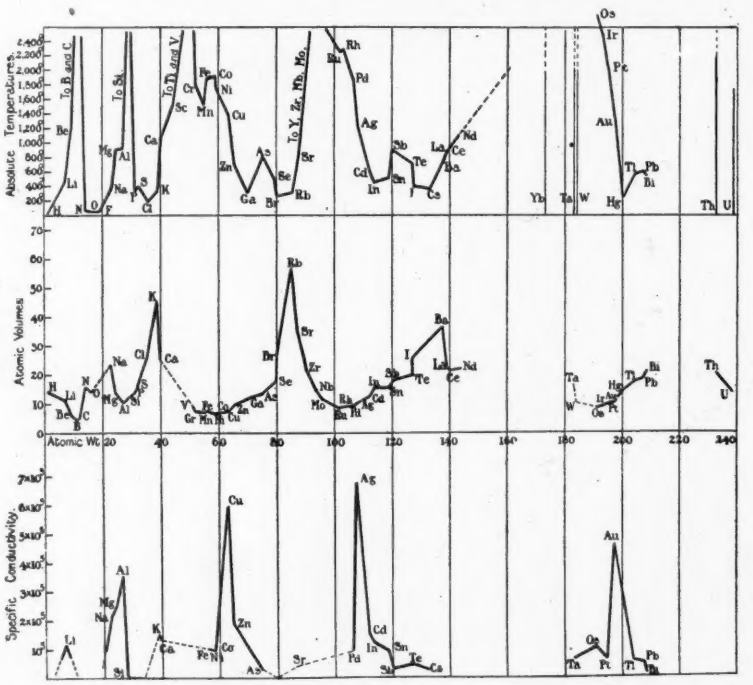
NEW INCANDESCENT LAMPS.[1]

BY J. SWINBURNE.

When we come to the question, "What metals or compounds are available for lamp filaments?" we have to consider the melting point, the specific resistance, and the possibility of making the filaments in practice. As to the melting point, it has been quite impossible to melt many of the metals until the electric furnace came into use; but the electric furnace generally deals with the metals in the presence of carbon, which probably alters their melting points. But apart from that, before the recent development of the study of radiation, there was no means of measuring such temperatures as the fusing point of tungsten, for example. Even yet we have no data as to the melting points of most of the refractory metals. The best guide available is the periodic law.

We may take what is generally known as the fourth group, and take the even series. This gives us carbon, titanium, zirconium, cerium, an element not yet discovered, and thorium. We may also take in, for consideration, boron, which is next to carbon, but in the third group, and silicon, which is also next to carbon, and in its own group, but in the third odd series. Then in the fifth group we may take the even series and get, after nitrogen, vanadium, niobium, didymium, tantalum, and an unknown element. In the next group we get, after oxygen, chromium, molybdenum, a ghost, and tungsten and uranium. In Series 6, running through Groups IV, V, VI, we get zirconium, niobium, molybdenum; and in Group VIII, rubidium, rhodium and palladium. Series 10, which contains tantalum and tungsten in Groups V and VI, has osmium, iridium and platinum in Group VIII. By using elements whose melting points are known to be high as a sort of guide posts, we can thus pick out the elements most likely to have high melting points.

Instead of using a table of elements we may work from curves. Fig. 1 shows three curves. In all the horizontal distance is the atomic weight. In the top curve the height is fusing point; in the middle curve, atomic volume; and in the lower curve, conductivity. It must be admitted that the information obtained is very vague, and it can be used only as a sort of index to show the probable directions for success. The melting points when high are very indefinite, so the peaks of that curve have been omitted. There are very few accurate data available as to conductivity of the metals.



CHARACTERISTICS OF ELEMENTS USED IN INCANDESCENT LAMP FILAMENTS.

It will be seen that the high melting points correspond with small atomic volumes. Electrical conductivity seems to follow the same sort of rule.

In making carbon filaments the practice is to make a thread of cellulose and carbonize it; but in early days it was proposed to make the filaments of a paste

[1] From a paper read before the Institution of Electrical Engineers of Great Britain on January 10.

such as lampblack and tar worked up. No practical lamps were ever made in this manner; but straight rods about a millimetre diameter were made as arc-light carbons, I think, by Messrs. Carré, and these were made into incandescent lamps. They were probably ground retort carbon made into a putty with sugar, treacle, or tar, and carbonized.

In making metal or carbide filaments there are several processes.

A carbon filament may be made first, and this may be coated by electrical heating with other substances, and the carbon can then be volatilized.

The same process can be carried out except that the carbon, instead of being volatilized, is combined, making a carbide. A wire may be deposited electrolytically from a solution.

The material may be ductile, in which case it is drawn into wire in the usual way.

The material may be made into a very fine, smooth powder, and mixed with some agglomerant, and squirted. The squirted filament is then dried, baked and heated electrically to get rid of carbon if an organic binding material has been used.

An oxide may be mixed with carbon and made into a paste and squirted. The filaments, after baking, are heated electrically *in vacuo;* the carbon then reduces the oxide, making either metal or carbide according to the proportion of carbon employed. The carbon may be supplied by heating in hydrocarbon vapor.

The oxide may be made into a rod and run like a Nernst lamp, except that the process is carried out either *in vacuo* or in hydrocarbon gas, so that the oxygen is removed, leaving metal. These are the most likely, or the least unlikely ways of making filaments.

The plan of coating a carbon and then volatilizing the carbon by heat has a heroic ring about it, which promises a lamp capable of very high efficiency; but I want to see it done. Most metals are likely to form carbides rather than let the carbon go off.

The Cruto lamp of about 1884 was supposed to be made by the converse process of depositing carbon on a fine platinum wire, and then heating the carbon till the platinum boiled off. The actual filaments were of such low specific resistance that platinum must have remained there.

The electrical deposition of metal filaments is generally troublesome because most of the metals that might do for lamps will not deposit uniformly enough, and electrolytic deposits of hard metals are not capable of being drawn down into wire. For such a process to be successful the core or mandrel must not be made of a metal that will form an alloy. It need not necessarily be metal at all; presumably such a material as nitrocellulose coated with blacklead, or made conductive by any of the ordinary methods, would serve. The resulting filaments would be tubes, of course.

Drawing down fine wire is generally impossible, as few of the metals are ductile. The drawing down of tantalum by Siemens and Halske is a perfect triumph when not only the real but the reputed properties of that metal are considered. Whether they draw the metal down by itself or by the Wallaston method I do not know. Tantalum is not soluble in the ordinary acids.

The metal filament is very seriously handicapped by its softness when hot and its brittleness when cold. Many of the metal lamps will run in only one position, otherwise the wire sags. The wires are also often very fragile when the lamp is not in use.

It might be urged that alloys should be used for lamp-wires, on the ground that many brittle and intractable metals may make ductile alloys. There is another point; alloys have generally high specific resistances, and this is, of course, a very great point. Even a very small addition of another metal may increase the specific resistance very considerably. Unfortunately alloys generally have low fusing points. Where a very fusible and a refractory metal are alloyed, the addition of the refractory to the fusible metal generally first lowers the melting point. The melting point then rises in one way or another, according to whether definite combinations occur, until the melting point of the refractory metal is reached. If the metals have about the same melting point, their alloy may be taken as having a lower melting point. This is not a law, however. The alloys of antimony and aluminum have much higher melting points than the component metals. Starting from pure antimony, the melting point falls a little on the addition of a small percentage of aluminum and then rises quickly. An alloy of aluminum and gold has also a higher melting point than either of its components. It is possible, therefore, that alloys may be formed which have very high melting points. Perhaps metals of the same group and series may give refractory alloys. Platinum-iridium has, I believe, a high melting point. Tungsten and osmium are in the same series, but are in the sixth and eighth groups. Tantalum and tungsten are in the same series and neighboring groups.

The addition of a very little of one metal to another may be worth while if it increases the specific resistance very considerably and lowers the melting point very little. Where you add a trace of infusible to a fusible metal the first result is generally to reduce the melting point; but after a very small percentage the melting point rises very rapidly. If you begin

TABLE I.[1]

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
1	H −269								He
2	Li 180	Be under 1,000	B	C	N −215	O 235	F 223	.....	Ne
3	Na 96	Mg 800	Al 657	Si	P 44	S 114	Cl −102		Ar
4	K 58	Ca 760	Sc	Ti 2,500	V 1,620	Cr 1,600	Mn 1,290	Fe 1,503 Co 1,500 Ni 1,427 Cu 1,084	
5	Cu 1,084	Zn 419	Ga 30	Ge 1,400	As 500	Se 250	Br 7		Kr
6	Rb 39	Sr 900	Y	Zr 1,300	Nb 1,850	Mo		Ru Pd 1,900 Rh 1,520 Ag 962	
7	Ag 962	Ca 322	In 176	Sn 224	Sb 632	Te 450	I 116		Xe
8	Cs 27	Ba 1,150	La 800	Ce 623	Di 940P 840N		Sm 1,350	.....	
9	.....	.....	Yb	.....	Ta Er 2,150	W above 1,900	.....	Os Ir 2,200 2,250 Pt 1,710 Au 1,064	.....
10									
11	Au 1,064	Hg −39	K 290	Pb 327	Bi 269		.....	.....	.....
12		Ra		Th		U			

[1This table, illustrating the periodic law, was submitted by Dr. J. A. Harker during his discussion of the paper. It gives the melting points of the elements, so far as known, in degrees centigrade. The table is reproduced from the *Electrician*, London.—Ed.]

with the infusible metal, the addition of the fusible component brings the melting point down very rapidly. In alloying two metals of about equal melting temperatures, the first addition of either brings the melting point down rapidly. The alloys with high melting points generally contain definite compounds, and compounds are often much more infusible than their components; ammonium nitrate, chloride, and chlorate are extreme but not apt examples. Arsenides and antimonides are not wholly unlike phosphides and even sulphides.

Alloying has a possible disadvantage in reducing the resistance-temperature coefficient. The rise of resistance is a most valuable property in a wire lamp, as it protects the lamp against overrunning, and allows it to be run bright on a more variable supply circuit.

One of the difficulties in squirting filaments of a paste of finely divided metals and an agglutinant is to get the metal fine enough to squirt smoothly. This is also a question of the agglomerant used. Some of these metals in the form of powder will not squirt properly; the paste comes out thin at first and then particles choke the nozzle and the squirting stops. Gum tragacanth is a very convenient material to use. It was used by Farneljehm for squirting thin threads of magnesia, out of which he made beautiful little baskets for use as mantles on water-gas burners. These have been supplanted by the Welsbach mantles. After a metal filament is squirted it must hold together until it is heated to a temperature high enough to sinter the particles together and make the filament into a sort of wire. Obviously it must be difficult to make very fine filaments in this way; and very fine filaments are necessary for reasonably high pressures. If the agglutinant is carbon there is a chance of its being taken up by the metal and either making the carbide or reducing the melting point, just as carbon reduces the melting point of iron or manganese.

Squirting a mixture of oxide and carbon and then electrically heating to get metal does not look promising because the resulting filament will probably contain carbon, or be a carbide, or else the metal will be only a sort of framework, as the volume of the metal must be less than the volume of the oxide plus enough carbon to reduce it. Such a filament will have a large diameter for a given weight of metal, and will most likely be very weak.

It may often be easier to squirt a very fine filament of pure oxide than of metal powder. The oxide can then be reduced, in many cases in hydrogen or even carbon monoxide, without forming carbide. In some cases I have found very fine "impalpable" powders can be made by calcining such salts as the oxalates. Prolonged kneading has a marked effect on the extrudibility of many pastes. A paste is much improved by being worked for hours in a small Pfleiderer, or by more powerful kneading. The attrition of the particles seems to grind the corners of the particles off. If you step on wet sand whose particles are sharp, the sand just round your foot looks dry, because the particles are moved out of their compact position, and constrain one another so that the interstitial spaces are increased, and the water is thus mopped up and drawn from the neighboring sand. On raising the foot the sand sinks back into compact positions, and looks wetter than ever. The same thing is noticed on a small scale with (unboiled) starch paste. The action is very marked, and starch and water will not squirt well. Gum tragacanth may act partly as a smooth cushion which prevents crystalline or angular particles locking; but prolonged kneading appears to grind off the corners.

A filament made by reducing a paste of oxide with hydrogen is also more likely to be dense and strong than one which had the reducing material in its body in addition.

The method of making a squirted filament of oxide and reducing it by running it as a Nernst lamp *in vacuo* is troublesome, and does not give much promise of supplying long, thin filaments. If you consider the length and diameter of the Nernst rod for 100 volts, and compare it with a tantalum wire for the same pressure, it is evident that the method is almost hopeless. A wire the length of a tantalum lamp filament and approximately of the same diameter could not be made of oxide, and could not be run as a Nernst filament with any reasonable pressure if made.

Though metal filaments have been referred to so far, it must be remembered that there is no reason to limit the possible conductors to elements. To begin with, we have the first of the new lamps, the Nernst, made of oxides. The Nernst is now so well known, and in such extended commercial use, that there is no need to say very much about it. The stick of oxides, or glower, as it is generally called, has such a high specific resistance that it need not be long and thin to meet ordinary conditions. On the other hand, the rods can not be made very thin, as the oxide is soft when hot, and is fragile when cold. The smallest rods made are for 0.25 ampere. On 100 volts these give about sixteen candles. The makers do not make rods to take 0.125 ampere so as to give sixteen candles on 200 volts. As the lamp requires a heater to start it, and an electromagnet to put the heater out of circuit, and a series resistance, or "ballast," it has always appeared to me the real field for the Nernst is not in competition with the sixteen-candle carbon incandescent, but in the region of fifty to 500 candles. The proportion of cost of the electromagnet, the resistance, and the heater is smaller in this case, and there is a more open field in competition with small arcs and Welsbach mantles.

I do not know what the Nernst glowers are made of now; they used to be a mixture, of yttria, or "yttrite earth" with zirconia, and it is probable the same or a similar mixture is still used. There may be a very large field for improvement here. The conditions are that the rod should stand a high temperature without getting too soft, and it should begin to conduct at a low temperature, so that starting should be easy. Nernst, no doubt, went over the ground pretty thoroughly in the first instance; but there are so many possible combinations that it looks as if there might be room for further good work. On the other hand, the lamp is of course patented, so there is not much encouragement for workers making improvements. It may be thought, however, that it would be better to employ some black substance, such as some oxides or sulphides which conduct even cold, so that preliminary heating might be omitted. It is a very curious thing that there does not seem to be any such black or colored compound in existence. There is a curious phenomenon in this connection. Some black or dark compounds, such as oxide of copper or oxide of vanadium, made in the ordinary way conduct well when cold, and can be heated electrically until fused, when they continue to conduct, of course; but if they are now allowed to cool they no longer conduct. Heating has changed their physical or crystalline state in some way. Both oxides of copper and vanadium are far too fusible for lamps. I do not think there are any promising sulphides. Most of the sulphides are easily fusible. As to the melting points of the tellurides and selenides, I am sorry to say I can give no information, as I am not at all well acquainted with those compounds.

It may be supposed that a Nernst glower should be run *in vacuo*, so as to avoid the loss by convection. The glower ap-

pears to conduct electrolytically exactly in the manner of a fused salt; and it would further appear that with a direct current you would get oxygen at one terminal and zirconium at the other, and that in a few minutes the glower would be entirely reduced to zirconium if the oxygen were pumped out as liberated. What really happens is that the lamp goes out. It does the same in an atmosphere of coal gas. This may be because the zirconium is liberated in a modification which does not conduct.

The metals may now be discussed in the order given by the periodic law.

Titanium is a metal with a very high melting point. It is comparatively plentiful, especially in Scandinavia; at least, I presume it is, as some years ago the owner of a titanium property was trying to find an outlet. I could not suggest any at that time.

Zirconium is said to fuse fairly easily; on the other hand, people are said to make lamps of it. As a matter of fact, it is not easy to get such a metal as zirconium pure, and it is quite possible the melting point is very high, and that some particular alloy that was really being examined melted more readily. Nearly all the melting points of such metals are uncertain. It is not very difficult to separate zirconium from other metals, even from thorium, if trouble is taken; but the purification by precipitation is exceedingly tedious, as the hydrate does not filter well. In addition, it is difficult to remove the alkali metals completely.

Zirconium lamps are made for up to 110 volts at one candle per watt. Whether they are made of zirconium or its carbide I do not know. Obviously if zirconium is not very infusible, lamps can not be made of it. Zirconium carbide I know from experience stands a high temperature.

Cerium is said to have a low melting point—below silver, in fact—and is therefore probably useless. I must repeat, however, that it is very difficult to get such metals pure. Cerium is very difficult to get approximately pure, as it is apt to contain other metals from the same group of earths. It is ductile. I do not know if a fine wire would be oxidized quickly on exposure to air. An alloy of cerium and iron makes sparks when filed or scratched; so it is probable cerium would be difficult to work into fine wires in the moist air.

Thorium—This metal has probably a very high melting point. Thoria is in great demand for gas mantles, and the demand has created a good supply, so there would be plenty for making filaments. I have tried running a thoria "Nernst" glower *in vacuo*. It can be started either by coating with platinum, by dipping in chloride and heating, or by a Ruhmkorff coil. A direct-current electrolyses it too quickly, and an alternating too slowly, so I superposed one on the other without the companies making any objections.

After some time the rod conducts when cold, and apparently consists largely of thorium, but there is difficulty with the connections. This method is applicable to the reduction of a large number of oxides.

Boron—Some work has been done on coating carbons with boron, but I have never heard that it was successful. Neither do I know if boron conducts at all. Of course many bodies that are really conductors will not conduct when they are in the form of fine powder, unless the powder is strongly compressed.

Silicon—In the early days of the carbon lamp, silicon was regarded as a possible rival, and some work was done on it. I do not know the result. The tetrachloride of silicon is a volatile liquid. I remember trying to deposit silicon on carbon filaments about twenty years ago by heating them electrically in an atmosphere of gas and silicon chloride, the idea being that the hydrogen of the gas would take the chlorine, and the carbon would get coated with silicon. I got no results. Much work has been done on these lines since, but I have not heard of any satisfactory result; and I have no reason to suppose they made better lamps than pure carbon.[1] Of course silicon deposited on carbon might form a coating of silicon carbide. Some years later a great deal of work was done on deposition of silicon from the chloride by Langhans.

In old days silicon was not a familiar substance, and, even if you made it, there seemed to be no way of making it into filaments. Now it is a commercial article. But this does not help us much, as, according to modern authorities, it is fusible at too low a temperature to be any use in this connection.

Vanadium—This seems a likely metal, but the fusing point is not at present known. It is not expensive.

Niobium—Very little is known about the physical properties of this metal. It probably resembles tantalum pretty closely.

Didymium—This has been separated into prazeodymium and neodymium by Welsbach; so the melting point of didymium, if determined, would only be that of an alloy. Didymium can only be separated into its elements by very long and tedious fractionation, and it is therefore practically impossible to get the metal pure enough to have a high melting point.

Tantalum is an exceedingly hard metal, and in its pure state is ductile. I do not know that any one knew it was ductile before Siemens & Halske's chemists tackled the matter. It was generally known as a powder only. It has a specific resistance of 16.5 microhm centimetres cold, or about eighty-five at the temperature of a lamp. It has a high tensile strength, namely, ninety-three kilogrammes per square millimetre, or fifty-nine tons per square inch.

It is drawn into wires of 0.05 down to 0.035 millimetres; the large wire gives twenty-five-candle-power lamps on 110 volts. Such a lamp has a filament of sixty-five centimetres, or 25½ inches long, and a pound of tantalum will make 20,000 of these lamps (Böhm). The tantalum is melted in an electric arc or furnace, and the ingots are heated red, and hammered into sheet, and the sheet is drawn down into wire. Whether it is drawn plain, or by a special method, there is no information. The metal is so hard that a diamond drill, run at 5,000 revolutions per minute for three days and three nights without stopping, only made a depression of a quarter of a millimetre or so. The experiment has been quoted a good deal, but one would like to know the state of the diamond drill. It may have lost its teeth in the first half-minute. Siemens & Halske intend to make various uses of the marvellous properties of tantalum, and we will probably soon have tantalum pens, drills, cutting tools, unoxidizable springs, and other desirable objects.

Siemens & Halske do not recommend their lamp for alternating currents, and it can not therefore be as good as on direct-current circuits; but it runs on alternating currents very well, though perhaps not as long. On the other hand it is said that the alternating current alters the physical nature of the wire, rendering it brittle, so that it breaks, not by fatigue, but by any slight shock it happens to get. The Nernst lamp has shown peculiarities in this connection. Some glowers will run with direct and not with alternating currents, and some with alternating only. Direct-current glowers also go wrong if the poles are changed. These mysterious properties of the Nernst do not seem to have anything to do with the behavior

[1 See ELECTRICAL REVIEW, January 19.—ED.]

of the tantalum lamp, however, but all the same there may be something in common. It is said that the makers have now overcome the aversion of tantalum lamps to alternating circuits. I have heard of tantalum lamps running on the County of London alternating circuits for over 600 hours with no failures. The makers attribute the breakages to the trembling action due to the repulsion of the wire near the bends. This will most likely be overcome by making the zigs and the zags so that the wire does not come close to itself. At present they are very acute angles. The wires are often in movement through a sort of Trevelyan rocker effect at the points of contact of the wire with its numerous supports.

Chromium is largely used in making chrome steel, but the metal itself is not often seen. It can be reduced from its oxide by aluminum. Its melting point seems to be high. I know of no work done on chromium filaments.

Molybdenum is very similar to tungsten, and unless the melting point is lower than that of tungsten, we shall probably soon have molybdenum lamps. The trioxide (the anhydride of molybdic acid) is volatile, and might therefore be used for deposition of molybdenum on a carbon filament, so as to replace it.

Tungsten is a very hard and brittle metal, which is sold in the form of a black powder, or a ferrotungsten. It was for a long time considered infusible, but the electrical furnace showed, of course, that it could be melted. The powder is difficult to squirt, even mixed with a good deal of tragacanth. Kuzel has invented what seems to be an admirable way of getting over the difficulty. He gets the tungsten in the form of an exceedingly fine powder by employing a method that was used by Bredig for getting what is known as colloidal platinum. An arc is made to play under water between tungsten electrodes, and this is said to produce a very finely divided form of metal. This is collected and worked up into a stiff enough paste and squirted. Tungsten is not an expensive metal, so the only cost is in making the filaments. Whether the filaments of this paste can be squirted so as to be fine enough for 200 volts will be a matter for the future to decide.

There have been processes proposed or worked in which carbon is heated in a vapor of a volatile tungsten compound, such as the trichloride, or oxychloride, in the presence of hydrogen. If the reduction in the case of a chloride is due to the hydrogen, thus involving no oxidation of the carbon, a filament must be obtained of carbon coated with tungsten, or of carbide of tungsten; but if there is any oxygen involved in the reduction, as in the case of the oxychloride, the carbon is burnt out, and the result is a filament of tungsten.

Uranium—It is doubtful if the melting point is sufficiently high.

Ruthenium is like osmium, but is said to fuse at a slightly lower temperature.

Palladium is the most fusible of its group, and is therefore useless for lamp filaments.

Osmium is a crystalline metal which can not be drawn into wire. It is very hard, scratching quartz. The Welsbach osmium lamp is said to be made by making a paste of finely divided osmium and an organic binding material, and squirting it. The filaments are then baked, and heated electrically to a very high temperature to eliminate the carbon. The osmium lamp so far produced is for low pressures, as might be expected, but it has a very high efficiency.

Making lamps of osmium must be an exceedingly difficult matter, or, at any rate, the problem of how to make them must have been very troublesome to solve. Apart from the metal being very hard and infusible, it oxidizes in the air if very fine, though this oxidation does not take place if the fine powder has been heated to a high temperature. The peroxide of osmium formed is very poisonous. It gives off enough vapor at ordinary temperatures to give much trouble, and especially to injure the eyes very seriously. This oxide might be used for replacing a carbon filament with osmium. No doubt that has been tried. The osmium was, I think, the first of the new metal lamps, and was invented by Auer von Welsbach. It is made up to seventy-five volts with forty candles by the Vienna firm, now the Westinghouse-Metallfaden-Glühlampfabrik, but 100-130-volt lamps of only thirty-two candles are supplied by the General Electric Company of this country. The rated efficiency is 0.8 candle per watt.

The osmium wire is said to be as small as 0.03 millimetre diameter, which is rather less than the finer tantalum wire.

There is some doubt whether the lamps known as osmium are made of osmium or an alloy of osmium with tungsten. Tungsten is a curious metal, and it is not very easy to get into alloys, but it may alloy with osmium perfectly for all I know to the contrary.

Iridium is a very hard and brittle metal. Iridium lamps are being studied by Gülcher. He makes a paste with an organic binding material, and squirts it. The filaments are then heated electricially until the carbon is burnt out, and some particles of metal have sintered together. This lamp, like other metal lamps, labors under the disadvantage of being only for low pressures. It would seem that squirted metal filaments are less likely to be made fine than those made from drawn wire.

The carbides of the various elements remain for discussion. It is difficult to know which have high enough melting points. A great many are said to be transparent, and are therefore non-conductors. Among these are the carbides of aluminum, cerium, lanthanum, lithium, silicon, thorium and yttrium. A great many decompose water, or are acted upon by the moisture of the air. This would make it very difficult to make lamps of carbide of aluminum, barium, calcium, cerium, glucinum, lanthanum, lithium, manganese, strontium, or uranium. Among the possible carbides left are those of boron, cromium, molybdenum, titanium and zirconium. I do not know anything about the carbides of palladium, tantalum or tungsten.

It will be asked, What will be the effect of these new lamps on the industry? In the first place they will increase the output of stations, just as machinery increases labor. But there is more difficulty in foreseeing the result of high efficiency hampered with low pressure. A probable solution is that people will gradually take to using large lamps taking the same pressure, and about the same power as carbon lamps, but giving, say, four times the light.

As to the lamp-making industry, one might prophesy without much danger that the present makers will merely alter their manufacture and make metal lamps. This will pay inventors better, because the existing makers have their commercial organizations and their facilities for distribution. Besides, all the works except the parts devoted to making the filaments will be available. It is possible new works will be set up to make filaments, and that the lamp makers will buy the filaments and make them up into lamps. There are so many possible ways of making metal filaments, that it is doubtful whether large monopolies can be secured by patents; and it is much more likely that most of the present carbon lamp makers will work out particular processes of their own, and will put their own metal lamps in the market.

The Tampa (Fla.) Electric Light Plant.

In 1893 the Consumers' Electric Light and Street Railroad Company purchased the water power plant of the Harney Lumber Company, situated on the Hillsborough river seven miles from the city of Tampa, then a city of 12,000 people. This plant consisted of a timber-crib dam and a wooden power-house. This was remodeled, and one 200-kilowatt railway generator and one fifty-kilowatt lighting generator installed, run by one thirty-six-inch, one forty-five-inch and two fifty-inch Leffel water-wheels on stone foundations.

The dam was ninety feet long, with stone abutments, with a capacity of fifteen feet head. This plant was used by this company up to 1897. The plant was too small for the demand for light and power, and in 1896, a new dam and power-house was started a mile and a half below the old dam. This dam consists of timber crib built up of logs, the most of which were found in the bed of the river and aged nearly to a state of petrification. The cribwork was filled in with earth and stone. The face is concreted over and curved to make an easy run for the water, and the foot is made of concrete. The foundation was set four feet below the bed of the river, and in the centre of the dam there is a four-foot concrete wall running from the wheel-pit walls to the gate walls. The dam is 126 feet long from the flume walls to the logway. There is a head of twenty feet, and by adding splash boards, twenty-three feet head can be obtained.

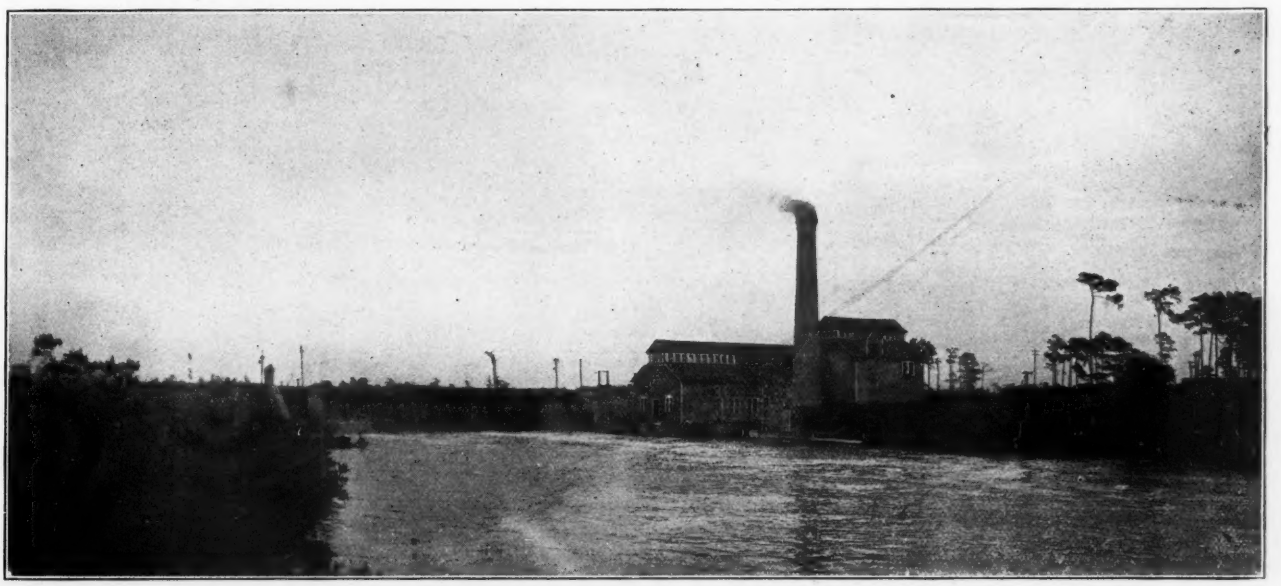
The gate or logway is twenty feet wide, constructed of removable plank to enable the reservoir to be drawn off and allow logs to pass over the dam. The gate timbers are set into concrete retaining walls on either side. The reservoir is maintained by two dirt wings, the one on the north side being 400 feet long and the one on the south side 150 feet long, with a line of matched pile through the centre.

The hydraulic equipment includes four pairs of thirty-six-inch McCormick horizontal water-wheels with a capacity of 1,400 horse-power at nineteen inches head. The wheels are set on a concrete foundation with concrete walls around the pits. Two pairs of wheels are connected together and belted to a jack shaft in the power house. The draught tube is seven inches in diameter and enters the tail-race under the power-house, walled up to maintain the necessary height of water to hold the vacuum. The wheels are governed by two Lombard water-wheel governors.

The power-house is built of wood, 133 feet by forty-seven feet. There are four 300-kilowatt, 6,600-volt, two-phase, 133-cycle Stanley generators divided into pairs; each pair being on the main shaft driven by engines and connected to the water-wheels by jack shafts. The jack shafts are connected to the main shaft by clutches.

The steam plant consists of one Atlas engine, tandem compound, twenty inches by thirty inches by thirty inches, and one Corliss twenty-two inches by forty-eight inches, giving a steam capacity of 850 horse-power, which can be used in connection with the water power. The boiler house is built of wood and contains six Bigelow boilers of 150 horse-power each. The stack is built of brick on the spoke idea with a base of fourteen feet and seven and one-half feet at the top, 100 feet high.

Current is sent out over a duplicate set of lines, each line having four wires, two for each phase, and run to a substation in Tampa, five miles from the power-house, at 6,600 volts. At the substation the current is stepped down to 2,400 volts for commercial purposes. The substation is equipped with two motor-generators, used originally for railway purposes, and now in case of an emergency, in case of a shutdown at the railway steam plant of the company.



DAM AND WATER-POWER STATION, TAMPA (FLA.) ELECTRIC PLANT.

Technical Publicity Association.

"Sales Night" of the Technical Publicity Association was held at the rooms of the Aldine Association, New York city, Thursday, January 31. The association received the first report of its circulation committee.

The companies represented by members at the meeting were: Yale & Towne Manufacturing Company, Johns-Manville Company, American Wood Working Machinery Company, F. R. Almond Manufacturing Company, General Electric Company, Crocker-Wheeler Company, American Locomotive Company, Cameron Steam Pump Works, New York Telephone Company, New York Edison Company, B. F. Sturtevant Company, A. A. Griffing Iron Company, A. Allan & Son, Goulds Manufacturing Company, Prentiss

Tool and Supply Company, J. G. Brill Company and Lidgerwood Manufacturing Company.

J. Robert Crouse described the plan of the Cooperative Electrical Development Association, already well under way, to stimulate the use of electric current in every branch of industry throughout the country, and A. L. Doremus, head of the sales division of the Crocker-Wheeler Company, of which he is vice-president and secretary, spoke on the relation of advertising to sales. W. J. Marsden, of the Yale & Towne Manufacturing Company, made some remarks on export trade.

The next meeting will be called "Railroad Night," at which a prominent railroad advertiser will be the principal speaker.

BOOK REVIEWS.

"Self-Propelled Vehicles." Fifth edition, revised and enlarged. J. E. Homans. New York. Theodore Audel & Company. Cloth. 598 pages. 6 by 8½ inches. Illustrated. Supplied by the ELECTRICAL REVIEW at $2.

In this book the practical features of motor vehicles are dwelt upon rather than the theoretical, the latter only being taken up when necessary for a clear explanation. A good part of the volume is given up to the gasolene vehicle, as at the present time this seems to be the one most in favor. The accessory apparatus is described by means of typical examples, no attempt being made to mention every method or apparatus that has been put out. There are several chapters devoted to electrical apparatus, such as motors, batteries and controllers.

"Engineering in the United States." Frank Foster. Manchester, England. The University Press. Boards. 106 pages. 6 by 9 inches. Price 1s.

There have been established at the University of Manchester, England, a number of scholarships for graduate students. These Gartside scholars, as they are called, are required to spend a certain amount of time in England, upon the Continent, and in the United States, studying various phases of engineering and manufacturing. The present volume is the result of twelve months spent in this country, during which the author not only visited various parts of the country, but spent some time as a worker in a manufacturing establishment and in a power station. The impressions which he obtained are in some cases favorable, but in others have led to criticism. As might be expected, a considerable part of the volume is descriptive. Chapter I discusses the general engineering policy, pointing out the tendencies towards specialization and to avoid unnecessary expense in finishing work. Chapter II deals with the relations existing between employer and employés. Here the greater freedom which the latter have in making suggestions is thought to be good. Chapter III deals with education, and is mainly a description of the methods followed. Chapter IV discusses the various phases of street railway work. Chapter V is concerned with wages and prices. Chapter VI with engineering establishments. Here the general policy of taking good care of the employés is warmly approved. Chapter VII deals with electric power stations. While much of the book contains nothing new to American readers, some suggestions may be obtained from the comments inspired by one who looks at matters from a little different point of view.

"Ice Formation, with Special Reference to Anchor-Ice and Frazil." Howard T. Barnes. New York. John Wiley & Sons. Cloth. 260 pages. 6 by 9 inches. Illustrated. Supplied by the ELECTRICAL REVIEW at $3.

The first part of this book discusses the physical constants of ice. It shows with what difficulty these have been determined, and gives the accepted values. Next the formation and structure of ice are taken up, first sheet ice, that form with which every one is familiar. It is followed by a study of what are called frazil and anchor ice. Sheet ice is formed only on the surface of still water, and it has a characteristic crystalline formation. If the water is disturbed by winds or by passing over rapids, frazil ice is formed; and it is this form of ice that gives the greatest amount of trouble to hydraulic power stations. The water freezes then in long, needle-like crystals which pack against the strainers, and, unless removed, will eventually close the inlet. Anchor ice is ice which is found attached or anchored at the bottom of a river or stream. It does not give much trouble. An interesting point brought out is the constancy of the temperature of the waters of the northern rivers. It has been found, after the most careful measurements, not to vary more than a few thousandths of a degree, and this fact accounts not only for the rapidity with which ice is formed, but it points out the proper method to be followed in fighting it. The last part of the book discusses the ice problem in engineering work. It has been found that radiation is the main cause of the formation of ice, as the temperature of the water itself remains very constant. Wherever radiation is prevented, as, for example, by a bridge or overhanging building, ice is not formed. This suggests that the sun may be utilized for preventing the clogging of intakes, as only a slight amount of heat is required to loosen the attached mass of ice from the grill. By exposing an ice-clogged grill to the sun, the attached mass of frazil ice may soon be removed. On the other hand, if the bars of the grill be exposed to the wind they become chilled below the temperature of the water and will hold any loosened mass of ice which may come in contact with them. It is suggested by Dr. Barnes that the most promising method of fighting frazil ice is to heat the grills by means of a well-insulated steam pipe. While, on first thought, this seems to be impracticable, as has been pointed out but a very slight change in temperature is needed to cause the attached ice to loosen; there is no necessity to heat up a large mass of water nor to melt all of the ice present. The book will be found not only of great interest scientifically, but very suggestive and helpful to engineers who are confronted with this winter problem.

The Commercial Value of the Microscopic Examination of Metals.

In an article dealing with the practical value of metallography, published in a recent issue of the *Revue de la Metallurgie*, M. Henri Le Chatelier remarks that while every one admits the interest and value of the microscopic examination of metals, many are disposed to question whether in practice the cost of the apparatus and equipment is not so large as to more than offset the value of the information thus obtained. Whilst he welcomes the fact that this considerable outlay on the part of manufacturing firms has popularized micrographic methods and established their value, he contends that this elaborate equipment is not really essential, and that a complete and efficient equipment can be provided at a cost much below that of the chemical laboratory of the works, and be run also at a very much smaller annual expenditure. He declares that microphotography is unnecessary, save where records are required for scientific purposes. The apparatus necessary for making the photograph is expensive, and the manipulation complicated. In works practice an eye examination through the microscope is all that is required, and the apparatus necessary for this costs only about eight pounds, instead of nearly eighty pounds. M. Le Chatelier continues that much of his own early work, including even the taking of photographs magnified 1,000 diameters, was accomplished with a microscope then thirty years old, to which he added, at a cost of eight shillings, a small mirror giving perpendicular illumination of the object. As for the operator, M. Le Chatelier does not consider a specialist necessary or even wise, and maintains that the chief engineers of the works should themselves examine the samples, as they now do fractures.—*Engineering (London), January 25.*

WARRANTABLE EXPENSE FOR METER TESTING.[1]

BY OLIVER J. BUSHNELL.

Probably the most important point to be considered in connection with our subject, is the frequency with which meters should be tested. Most central station managers believe that, as a matter of general policy, meters should not run much longer than a year without testing, both as a protection to the company against loss, and as an assurance to their customers of the correctness of their bills. These men would doubtless also assent to the proposition that it would pay to give special attention to meters involving a large amount of income. We can not, however, arrive at the proper frequency of tests with any correctness without a study of the conditions which affect meter accuracy.

We find that in all meters the revolving part is mounted on a jeweled bearing which in time becomes rough; again, that the permanent drag magnets are liable to change from aging, rough handling or short circuits; again, that in commutator-type meters the commutator and brushes will wear and become rough from sparking; lastly, that all meters are influenced more or less by vibration, dampness, dust and other conditions of installation. Jewel wear, the first of these causes which affect meter accuracy, is influenced chiefly by the weight of the moving element, the number of revolutions of the shaft and vibration. The first of these is constant for a given type of meter, the second is easily ascertained from the meter readings, and the influence of the last can be learned from successive tests.

Just how much wear a jewel will stand is somewhat uncertain. Sapphire, which is almost universally used, is of uneven structure, and variations in the quality of jewels can not be eliminated by the most careful inspection in their manufacture. In a report on "Jewels and Pivots" in commutator meters made a few years ago by the Meter Committee of the Association of Edison Illuminating Companies, it was suggested as a result of about 200 time tests that 800,000 revolutions be taken as the limit of wear of sapphire jewels in meters not subject to vibration, with half that number as the limit where vibration was constant. Since that time commutator-type meters have been very much improved and in the latest type the weight of the moving element is only one-third as much as formerly. It does not appear that the decrease in jewel wear is directly proportional to the decrease in weight of the moving element, but it is probably nearly so. It would doubtless be more accurate to adopt a different limit of revolutions for each type of meter in which the weight of the moving element is different, but for convenience 1,000,000 revolutions has been quite generally adopted as the limit of wear for sapphire jewels in all commutator meters.

The writer has not any direct data on the wear of sapphire jewels in induction meters and here again the weight of the moving element varies in different types of meters; but from a comparison of these weights with those of the moving elements in commutator-type meters and from the lesser number of jewels found defective in annual tests of induction meters, it is evident that a jewel will stand at least two or three times the number of revolutions in an induction meter that it will in a commutator type. The writer believes the limit of wear of 2,000,000 revolutions, adopted by a large eastern company, is certainly safe.

About two and one-half years ago there was discovered a process of cupping diamond jewels for meters and since then they have come into considerable use. One company has made tests of these jewels up to 9,500,000 revolutions without the stone showing any wear, but in some of the tests the shaft points became so flat as to introduce considerable friction. What the average life of the jewel is we can not state, but believe that it can safely be taken at five times that of sapphire jewels and that it is probably more than this. Although the adoption of diamond jewels largely removes jewel troubles, the elements of magnet change, commutator friction and deterioration due to local conditions still remain to be considered. These are so uncertain that they can not be classified directly and the old limits of registration between tests originally adopted for sapphire jewels have been adhered to quite generally among those companies which are using diamond jewels on account of possible deterioration from these other causes.

There is an important fact also in meter construction to be considered in this connection which makes the size of the meter an element to be considered in determining the frequency of tests. Meters of a given make have approximately the same full load torque in all sizes. It follows that a meter of large capacity will at times necessarily operate with much less torque than a meter of small capacity with a resultant increased liability to error. To illustrate, suppose a five-ampere 100-volt meter and a fifty-ampere 100-volt meter are both recording a load of 1-50 watt lamp. The first is running on a ten per cent load with ten per cent of its full load torque and the other on a one per cent load with only one per cent of its full load torque. As the full load torque of both meters is the same it follows that the small meter has ten times as much torque on one lamp as the larger one. Suppose also that it takes one-half of one per cent of the full load torque to overcome the friction of the bearings, the small capacity meter would run five per cent slow while the large capacity meter would run fifty per cent slow on the fifty-watt load. It is at once evident that meters of large capacity should be kept in better condition, and more frequently tested than those of small capacity.

In acordance with the foregoing considerations meters should be classified for testing somewhat as follows:

First—A limit should be set within which all meters should be tested.

Second—A classification should be made according to sizes so that the large meters will be tested oftener than the small ones.

Third—A classification should be made according to the work done by the meter so that they will not be allowed to exceed a fixed number of revolutions between tests.

Fourth—Changes in classification should be made to allow for local conditions as made evident by the results of successive tests.

In order to find out the methods now used in meter testing, the writer sent out a number of questions on the subject to twelve of the largest companies in the country. The first two were as follows:

First—How often are your electricity meters tested?

Second—On what basis is the frequency of tests determined?

The following are four of the answers received:

First Answer—(1) By inspection once a year. (2) The basis of the frequency of tests is assumption that meters should be inspected at least once a year.

Second Answer—(1) From one month on largest meters to fifteen months on induction meters in residential districts, all meters coming as a rule within either one, three, six, nine or twelve months' classes. (2) On the basis of the work which the meter is doing, the intention being to test at every million revolutions of the disc

[1] A paper read before the Northwestern Electrical Association, Chicago, Ill., January 16.

in direct-current meters and every two million revolutions in induction meters.

Third Answer—(1) As a general rule once in twelve months, some are tested monthly, three monthly and six monthly. (2) The period is decided by the amount of the monthly registration varying, of course, with the various sizes of meters. All meters tested more than once a year are equipped with diamond jewels. Our data shows that a meter equipped with a diamond jewel need not be tested until it has made a million or more revolutions.

Fourth Answer—Our meters are tested each time they are returned to meter shop, regardless of time they have been installed. Others that have been installed three years are changed, tested and cleaned up. We do not test meters on customers' premises unless requested to do so.

Commenting on these replies, the writer believes that the first system must result in the meters measuring the largest consumption showing the poorest accuracy.

The second tends to keep all meters on a level of accuracy at the same per cent loads, but will result in a disproportionate loss from the large capacity meters on light loads.

The third system, which takes the size of the meter also into account, will not only keep up the accuracy of the meters under heavy service, but will also maintain the accuracy of the large capacity meters operating considerably under light load conditions.

The fourth system, the writer believes, is faulty both in allowing too long a time between tests, even for induction meters, and also in the method of testing, which will be taken up later.

The classification adopted by the writer about two years ago for commutator meters was as follows:

Annual tests for meters of five to ten amperes capacity.

Semi-annual tests for meters of fifteen to fifty amperes capacity.

Quarterly tests for meters of seventy-five amperes capacity and above.

Meters making over 1,000,000 revolutions of the disc between tests on above classification to be changed to more frequent class so as not to exceed that number between tests, up to the quarterly class.

It has not been thought necessary to test any meter oftener than once in three months. Where a meter has not retained its calibration for this length of time an investigation has been made. Such rapid loss of accuracy is usually found to be due to commutator trouble caused either by excessive vibration or heavy momentary overloads. In the first case the meter has been moved or mounted on a springboard, and in the latter a larger meter has been installed with a better resultant accuracy than if the old meter had been left as it was and tested monthly. All meters tested quarterly have been equipped with cupped diamond jewels and the semi-annual class are being so equipped as rapidly as they can be obtained.

A study of the data compiled from the tests made according to the foregoing schedule reveals some interesting facts. In the first place the accuracy of the meters improves in an increasing ratio the more frequent the testing. The quarterly tests at one-half load show fifteen per cent more of the meters to be accurate than the annual tests, and ten per cent more than the semi-annual tests, while the improvement shown by the light load tests, which are made at one-tenth load, is still more marked. The same increasing ratio of improvement the more frequent the testing, is seen in the average accuracy obtained from these tests which was as follows:

Annual tests	½ load 97.3%	1–10 load	89.6%
Semi-annual tests	½ load 97.8%	1–10 load	90.8%
Quarterly tests	½ load 99.1%	1–10 load	96.5%

An important showing from the data of the meters out of calibration is the ratio of the meters slow, to those fast, which at one-half load was more than two to one, while at one-tenth load it was five to one. On still lighter loads the ratio would doubtless be further largely increased. It was also shown by the data that the type "C" commutator meters maintained their accuracy much better than the older types with heavier moving elements, especially on light loads where the greatest improvement was needed. A better accuracy was shown by the annual tests of type "C" meters than by the semi-annual tests of meters of the older types.

The writer has not given the above schedule, however, as a model, but rather as an illustration. In the light of the results obtained he expects to make some changes for the coming year. It would seem as though some differences should be made in the classification of commutator meters as regards the type, though the use of diamond jewels in all of the older types may largely obviate the necessity. In particular, however, it would doubtless be advantageous to test more of the meters quarterly, placing at least more of the meters of the older types in this class.

Induction meters have so far been classified by the writer on an annual basis for testing. Owing to the light weight of the moving element and the absence of commutator friction these meters retain their accuracy much better than the commutator type. Data compiled from about 14,000 annual tests showed an accuracy almost identical with that of commutator meters under quarterly testing. As it is probable, however, that the meters measuring the largest consumption are below the general average, it is expected the coming year to test the larger meters and those showing over 3,000,000 revolutions between tests on a semi-annual basis.

Having decided on some schedule for periodic testing an important point to be next considered is the advisability of making installation tests. It is well known that meters transported some distance are liable to slight changes in calibration, also that direct-current meters, unless connected according to polarity markings or even if so connected where influenced by magnetic fields from other conductors, will show some error on light loads. The questions sent out by the writer brought back the information that two of the largest companies in the country make a test on every meter installed before the first bill is rendered, notwithstanding the fact that the meters have previously been corrected in the testing room. In the Chicago Edison Company it has been the practice to have all meters after installation inspected, and cleaned and adjusted if necessary, so as to run freely on a light load. In order to get some information as to the condition of meters after their installation and as to whether an inspection or test is advisable, the writer made 100 tests of commutator meters and 100 tests of induction meters immediately after they were installed, these meters having all been adjusted in the shop before being sent out. The accuracy after installation as shown by these tests was rather disappointing, especially so in commutator meters on light loads. Tests were then made on an equal number of meters after the usual starting inspection. These tests showed a decidedly improved condition of these meters over the others, especially on light loads, and a better accuracy than that shown by any of our periodic tests. Still there were some meters which showed a change of from five to ten per cent in their whole calibration. It is particularly desirable that the bills of a new customer should be absolutely correct. If a meter is slow for two or three months and then is corrected, it leads to the suspicion when the bill goes up that the company is increasing the bills arbitrarily

after it feels sure that the customer will be permanent. The conclusion seems warrantable that both alternating-current and direct-current meters involving considerable consumption ought to be tested within one month after installation. The direct-current meters will be left in a more permanent condition if allowed to run for two weeks before testing so that the commutator will have become oxidized. For the large class of small meters for offices, apartments and houses a careful inspection appears to be a sufficient safeguard. Perhaps a good division would be that meters which it is advisable to test oftener than once a year should have an installation test and others an inspection only.

The methods of testing should have some attention, which of necessity is very much abbreviated. The first important point is to have accurate standards. A laboratory standard voltmeter, a standard shunt and a precision indicating wattmeter make excellent working standards. These should be returned to the factory occasionally for calibration unless the company has a laboratory where they can be checked. In the absence of these a set of the working instruments should be kept for checking other instruments only, and returned to the factory for recalibration every six months.

Meters can be tested on the customer's premises or brought in and tested in the shop. Some have contended that the latter is the more accurate way as conditions are more favorable for correct measurements. The necessity for installation tests which is shown in a previous part of this paper proves conclusively, however, that meters should be tested under local conditions in which they are to operate, and after all danger of change from transportation is over. Even if a meter is taken out and installed with the utmost care so as not to disturb the original calibration in the slightest, frequently some change in the light load adjustment is necessary to adapt it to local conditions of vibration or adjacent magnetic fields.

Four methods of testing are in general use:

First—With ammeter, voltmeter and stop watch.

Second—With calibrated resistance, voltmeter and stop watch.

Third—With indicating wattmeter and stop watch.

Fourth—With check recording wattmeter.

The first method is used only on direct-current work and the second should be only so used unless the resistance is absolutely non-inductive. Self-contained shunt Weston ammeters, on account of temperature error, should not be used except in small sizes, and even then the current should be kept on the instrument only during the time necessary to make each test. Resistance shunts with negligible temperature coefficient and milli-volt meters should always be used for measuring large currents. The indicating wattmeter should be used only for alternating-current work, as it is not reliable to direct current, owing to the influence of external magnetic fields. The check-recording wattmeter has the advantage of not requiring a stop watch, yet if a portable load is used the inspector can tell the per cent load on the meter with sufficient accuracy. An ordinary meter can be placed in a carrying box and used for checking, but it is better to use one of the special test meters of which there are two or three kinds on the market. These meters are built with several field windings so that the full torque of the meter is available at different loads. The meter under test can accordingly be tested with equal accuracy at heavy and light loads by connecting to the field coils of the corresponding capacity in the test meter. This method is particularly advantageous where a meter must be tested on a fluctuating load.

Each method of testing has it advantages and each will be found best doubtless for some kinds of work. The writer has had all in use and finds no particular advantage of one over the others in the amount of work which can be accomplished. He inclines to the belief, however, that the test meter with several field windings will soon have more general adoption and prove slightly more economical than other methods.

The number of meters which can be tested by an inspector in one day has been variously reported by the different companies from which data was secured at from six to ten. The writer believes an average of about seven should be obtained in testing commutator meters and eight or more in testing induction meters.

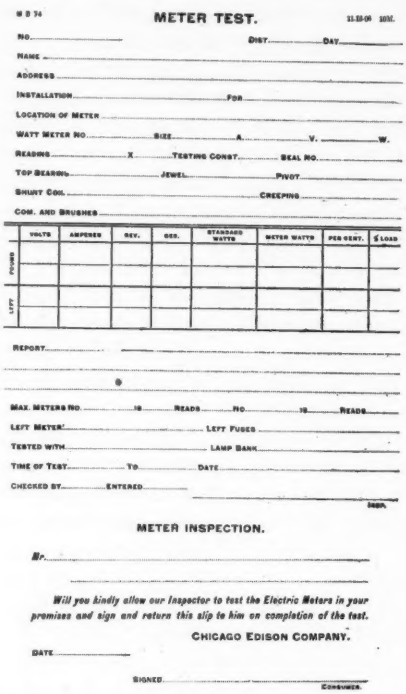
The use of diamond-cupped jewels is recommended in all of the older type commutator meters where the jewel is subject to heavy wear. Sapphire jewels may be once repolished but the stones should be removed from the screws and polished and inspected the same as new stones and set in new screws. If polished in the old setting some of the powder is apt to be left in the screw and cause trouble. Pivots also may be used a second time if they are carefully repointed and polished. A new pivot or shaft should always be inserted when a jewel is changed.

It is advisable to test meters at two points. The light load calibration is usually made at one-tenth load and heavy load at from one-half to full load. It makes no difference whether one-half or full load is used as far as the final calibration of the meter is concerned, but the reports of the meters as found would doubtless show better on a full load test. One-half load is used by the writer as being nearer the running condition of the meter.

Whatever tests are made an accurate record should be kept and the results carefully tabulated. Sample forms for this purpose are appended to this paper. Only by an accurate knowledge of the condition of his meters and a study of the results of his testing can a central station manager satisfy himself as to whether or not he is warranted in the expense he is incurring.

We come now to the question which many may consider the most vital to the subject. What will a thorough system of meter testing cost? Whatever is said on the subject will doubtless be questioned by a good many, as the practice of different companies varies so much, both as to the amount of testing and the expense items which are included under this head. The expense in the same company also would vary with the character of the customers served and the amount of consumption measured. Nevertheless approximate figures may be arrived at as a general guide to good meter practice. These figures might be expressed in cents per kilowatt-hour generated output or in per cent of metered income, but it seemed to the writer that they would be more readily understood and of more accurate application if based on the number of meters in service. The writer collected some data on this subject, but the classification of accounts varies so in different companies that the figures are not readily comparable or all applicable to the expense of meter maintenance only. Meter testing, in the broad sense we wish to use, should include all maintenance expenses and cover periodic testing, shop testing and repairing and installation tests and inspections. The money actually spent on this work in different companies from which figures were received varied from forty-eight cents to $1.63 annually per meter installed. The writer must accordingly draw largely on his own experience and the figures of the companies with which he is connected for his conclusions. Naturally the ex-

pense for direct-current meters is greater than for induction meters. It is customary also to distribute direct current largely in business districts where the wear on the meter is greater on account of longer use, and alternating current in residential districts. A thorough system of testing based on the principles outlined in this paper can not be carried on, according to the estimate of the writer, for less than about seventy-five cents per meter installed for induction meters, and $1.50 per meter installed for commutator-type meters annually. It is possible that there are some companies with few large customers and little increase in busines, which could do the work for two-thirds these figures, but for a progressive growing company they are not too high. These figures include the cost of all instruments, apparatus and supplies necessary for carrying on the work as well as the cost of material used in the meters and labor. The salaries of meter testers is assumed to be from $50 to $65 per month for the most part and helpers for testing large meters at $40 per month. It must be borne in mind that the amount given will not be spent on every meter. A third of it would cover the cost for a large part of the meters which are tested annually, but two or three times this amount would be necessary for other meters which are tested quarterly. The general average is also brought up by the cost of installation tests and inspections, and of repairs to defective meters, together with the cost of instruments and general supplies. These figures are based on a system of testing which experience has shown to be advantageous. It is not the intention, however, to limit the expenses to these amounts as further experience may demonstrate the advisability of still more expenditure for this purpose. Of course for meters measuring little consumption, the limit of expense is reached when reasonable accuracy is obtained, but for meters measuring a large consumption the cost of meter maintenance may be inconsiderable as compared with a loss of a fraction of one per cent in registration. The high cost for direct-current meters is partly on account of the introduction of cupped-diamond jewels. These cost about five times as much as sapphire jewels, but their use is fully warranted both by the better accuracy obtained and by the longer life of the jewel. The Chicago Edison Company has put in service over 3,000 of these jewels in the last two years, half of which have been in use over a year and as yet only about one per cent of them have become worn. Compare these results with data on sapphire jewels of which forty to sixty per cent are found defective in annual testing and the value of the cupped-diamond jewel is readily apparent.



METER TEST.

NO. ..... DIST. ..... DAY. .....

NAME .....

ADDRESS .....

INSTALLATION ..... FOR .....

LOCATION OF METER .....

WATT METER NO. ..... SIZE ..... A. ..... V. ..... W.

READING ..... X ..... TESTING CONST. ..... SEAL NO. .....

TOP BEARING ..... JEWEL ..... PIVOT .....

SHUNT COIL ..... CREEPING .....

COM. AND BRUSHES .....

	VOLTS	AMPERES	DEV.	DEG.	STANDARD WATTS	METER WATTS	PER CENT.	% LOAD
POWER								
LIGHT								

REPORT .....

MAX. METERS NO. ..... READS ..... NO. ..... READS .....

LEFT METER ..... LEFT FUSES .....

TESTED WITH ..... LAMP BANK .....

TIME OF TEST ..... TO ..... DATE .....

CHECKED BY ..... ENTERED .....

METER INSPECTION.

Mr. .....

Will you kindly allow our Inspector to test the Electric Meters in your premises and sign and return this slip to him on completion of the test.

CHICAGO EDISON COMPANY.

DATE .....

SIGNED .....

Consumer.

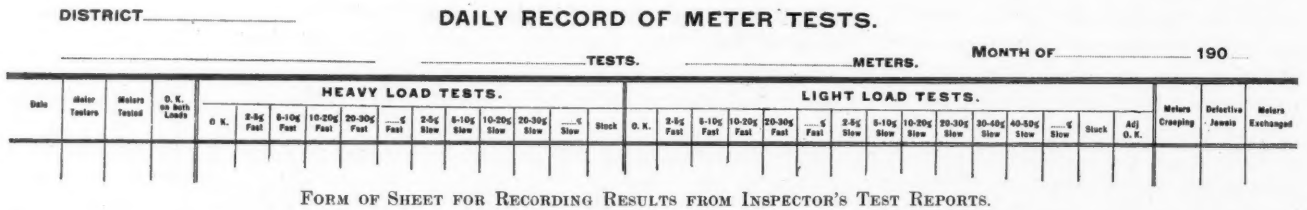
FORM OF SHEET FOR TABULATING METER TEST BY INSPECTORS.

It may be objected that not yet has it been shown that the estimated expense for meter testing is warrantable. The reply in the first place is that any reasonable expense is warrantable which will make a company's bills accurate and its dealings with its customers honest. In the second place that in all probability the expense will be more than met by the increased revenues from accurate meters. This statement is difficult of demonstration as we are unable to know just what the accuracy of the meters is under working conditions, either with or without testing, but we will give two illustrations which will hardly leave any doubt as to its truth.

About two years ago the Chicago Edison Company changed from a system of annual testing, with semi-annual testing of a few of the largest meters, to the classified system outlined in this paper. Under the old system the meters ran from fifteen to sixteen months between tests owing to interruptions in the work and changes of inspectors. After the change sufficient help was employed to keep the work strictly up to the schedule. As a result of this testing the unaccounted for output decreased from 8.7 per cent to 7.1 per cent of the total generated showing a saving of 1.6 per cent. As the generated output for the year was 76,454,000 kilowatt-hours the saving amounted to 1,223,264 kilowatt-hours. This represents additional energy paid for, so to determine the income saved to the company it must be multiplied by the average price received. Assuming this to be seven cents per kilowatt-hour, we find the saving amounted to over $85,000. This is sixty per cent more than the total meter department expense, about three times the total expense for testing and repairing meters, and eight times the additional expense over that previously expended for testing.

Take another example. In a suburb near Chicago the meters had been allowed to run much as they pleased for several years. A year ago they were all overhauled and some of the old types discarded. This fall the income showed an increase of thirty-eight per cent over the previous year and one-half of this increase was attributed by the manager to the improved accuracy of the meters.

Meter testing, however, as stated above, is a matter of ethics as well as economy. Suppose your average accuracy is at present so high that the cost of testing will not be covered by the increased income, still it is the duty of lighting companies to take all possible precautions to prevent inaccuracies in their bills. Fortunately the meters manufactured to-day retain their accuracy better than those of a few years ago and when these older types have all been worn out or discarded it is hoped that less frequent testing will be necessary. Present conditions, however, demand that companies should give more attention to meter testing than is ordinarily done. It is also a fact that those companies which have done the most in this line best appreciate its economic value.



DISTRICT ..... DAILY RECORD OF METER TESTS.

..... TESTS. ..... METERS. MONTH OF 190

Date	Meter Testers	Meters Tested	O. K. on Both Loads	HEAVY LOAD TESTS.											LIGHT LOAD TESTS.														Meters Creeping	Defective Jewels	Meters Exchanged
				O. K.	2-5% Fast	5-10% Fast	10-20% Fast	20-30% Fast	....% Fast	2-5% Slow	5-10% Slow	10-20% Slow	20-30% Slow	....% Slow	Stuck	O. K.	2-5% Fast	5-10% Fast	10-20% Fast	20-30% Fast	....% Fast	2-5% Slow	5-10% Slow	10-20% Slow	20-30% Slow	30-40% Slow	40-50% Slow	....% Slow	Stuck	Adj O. K.			

FORM OF SHEET FOR RECORDING RESULTS FROM INSPECTOR'S TEST REPORTS.

ON THE SUBSTITUTION OF THE ELECTRIC MOTOR FOR THE STEAM LOCOMOTIVE.[1]—II.

BY LEWIS B. STILLWELL AND HENRY ST. CLAIR PUTNAM.

"MAINTENANCE OF EQUIPMENT."

Item 11. "Cost of superintendence" will not be changed.

Item 12. "Repairs and renewals of locomotives" amounts to 7.509 per cent of the average operating expenses of our steam railroads. This item, as we find in the classification of operating expenses prescribed by the Interstate Commerce Commission, "does not include the expense of cleaning boiler tubes and packing cylinders, nor ordinary regular inspection, this being charged to the item 'Engine and roundhouse men'." It does include "all expenditures for account of repairs and renewals and rebuilding of locomotives, tenders, snow-plows (when attached to locomotives), furniture and loose and movable tools and supplies used in connection therewith. It also includes the cost of locomotives, tenders and appurtenances thereunto belonging, built or purchased to make good the original number charged to construction or equipment."

As regards "Repairs and renewals of electric locomotives," actual experience to date is not sufficient to justify us in fixing a figure for this item which can be regarded as established. There is, however, evidence sufficient to justify an estimate which in the average case should be approximately correct.

For the year ending June 30, 1901, the car-mileage operated by the Manhattan Elevated Railway was 43,860,158. The cost of repairs of steam locomotives was $173,609, or 0.39 cent per car-mile.

For the year ending June 30, 1906, the car-mileage operated by the Manhattan Elevated Railway was 61,723,112. The cost of repairs of the electric equipment, including lamps, lamp wiring, and heaters, was $171,927, or 0.28 cent per car-mile.

Had electric locomotives been used instead of the multiple-unit system, the number of parts constituting the electric equipment would have been about one-third that now in use. These parts would have been larger and more expensive than the corresponding individual parts constituting the multiple-unit equipment, but the cost of repairs of the aggregate electrical equipment (which is largely labor of inspection) probably would not exceed sixty per cent of the present cost. The results are further influenced unfavorably to electric traction as regards this comparison by the fact that the speed, and consequently the power consumption per car, have been radically increased, and by the fact that the repairs and renewals of lamps, heaters and wiring are included.

A careful consideration of the detailed factors involved has led to the conclusion that had electric locomotives been substituted for steam locomotives, and had the weight and speed of trains not been increased, the cost of repairs of electric equipment would have approximated 0.2 cent per locomotive mile. We estimate also that the cost of repairs to these small locomotives exclusive of their electric equipment operating under the existing conditions would not have exceeded 0.2 cent per locomotive-mile, and that the total cost would have approximated one-fourth of the cost of the corresponding item under steam traction. This figure, of course, is available only as a ratio in our consideration of the general railway problem.

The very low cost which was actually obtained in the case of steam locomotives on the Manhattan; *viz.*, 1.57 cents per locomotive-mile, is explained by the extremely simple construction of the engines, the fact that they were not overloaded, were operated on an elevated structure, and were admirably maintained. It is also to be noted that the amount expended for repairs was minimized in view of the contemplated adoption of electricity.[1]

For the year ending June 30, 1906, the car-mileage operated by the New York Subway was 31,931,073. The cost of repairs and renewals of electric equipment of rolling stock was 0.38 cent per car-mile. Estimating the probable cost of repairs and renewals of electric equipment, were electric locomotives in use instead of the multiple-unit car equipment, the approximate cost in this case works out at 0.7 cent per train-mile. A locomotive doing the same work as the electric equipment of the average train in the subway (about five cars) must be capable of exerting a draw-bar pull of 30,000 pounds, which, with twenty per cent adhesion, call for seventy-five net tons on drivers. This is about double the weight on drivers of the average steam passenger locomotive, and the figure 0.7 cent per train-mile, obtained in actual service under conditions very severe in respect to maintenance of electric equipment, by reason of the presence of great quantities of brake-shoe dust, is to be compared with the cost of maintenance of steam locomotives exclusive of running-gear, frame, cab and those other parts common to both electric and steam equipment.

Operation for the Year 1905 of the Wilkes-Barre & Hazleton Railroad—

TABLE I—*Continued.*

Item	Amount 1905	Per cent. 1905	1904	1903	1902	1901	Average Five Years	Estimated Cost of operation by Electricity
Maintenance of Equipment	288,012,604	20.765	19.967	19.133	19.127	18.629	19.524	12.287
11. Superintendence	7,831,965	0.565	0.567	0.559	0.601	0.599	0.578	.578
12. Repairs and renewals of locomotives	114,988,428	8.290	7.904	7.408	7.246	6.695	7.509	2.253
13. Repairs and renewals of passenger cars	27,342,129	1.971	1.951	2.044	2.157	2.277	2.080	2.080
14. Repairs and renewals of freight cars	113,723,239	8.199	7.777	7.442	7.432	7.436	7.657	6.000
15. Repairs and renewals of work cars	3,360,390	0.242	0.231	0.242	0.245	0.233	0.238	0.238
16. Repairs and renewals of marine equipment	2,650,543	0.191	0.154	0.177	0.215	0.234	0.194	0.194
17. Repairs and renewals of shop machinery and tools	9,186,101	0.663	0.704	0.696	0.643	0.605	0.662	0.500
18. Stationery and printing	595,571	0.043	0.042	0.046	0.044	0.043	0.044	0.044
19. Other expenses	8,334,240	0.601	0.637	0.519	0.544	0.507	0.562	0.400

NOTE.—It is customary with some railroads using electric equipment to include under the general heading "Maintenance of Equipment," the maintenance of the power plant and electric transmission systems. Both of these, however, are more conveniently treated by including them in the cost of electric power delivered to the overhead trolley system or third rail.

[1] A paper presented at the 218th meeting of the American Institute of Electrical Engineers, New York, January 25. Condensed.

[1] In this connection it is interesting to note that the cost of maintenance of locomotive and average train under steam operation for the year ending June 30, 1901, was 4.2 cents per train-mile, while the cost in the case of an equivalent electric train, as shown by records for corresponding months for the year ending June 30, 1906 was 2.1 cents per train-mile.

The equipment comprises motor-cars weighing forty-three tons without passengers, and equipped with four 125-horse-power motors and multiple-unit control. The effective draw-bar pull, (twenty per cent adhesion), is 17,000 pounds. The speed of operation in local service is thirty miles per hour. The total length of run is twenty-seven miles. The average number of stops is six. The car-mileage operated in 1905 was 262,947.

Cost of repairs and renewals of electric motors was $1,021.70, or 0.39 cent per car-mile.

This road operates in a mountainous country, ranging in elevation from about 500 feet to 1,700 feet above sea-level. About one-third of the length of the road is on a grade of three per cent.

Operation of the Lackawanna & Wyoming Valley Railroad for a Period of Four Months ending October 31, 1906—Equipment: a, sixteen passenger cars, 77,500 pounds each; b, fourteen passenger cars, 64,500 pounds each; c, four freight and express motor-cars, 61,300 pounds each; d, one electric locomotive, 94,600 pounds.

The car-mileage operated was 527,554.

Cost of repairs and renewals of electric equipment was $4,450.43, or 0.84 cent per car-mile.

Operation of the Niagara, Buffalo & Lockport Railroad for a Period of Six Months ending November 30, 1906—Equipment: passenger cars weighing about 60,000 pounds, driven by four direct-current motors.

Average speed outside of Buffalo city limits, twenty miles an hour. Approximate number of stops one way trip: thirty on Buffalo & Niagara Falls division and six on Buffalo & Lockport division; length of run outside of Buffalo, approximately twenty miles; car-mileage operated, 1,309,682.

Cost of repairs and renewals of electric equipment was 0.79 cent per car-mile.

Perhaps the best instance of electric operation directly comparable with cost of steam operation is afforded by the records of the actual results realized on the Rete Adriatica-Valtellina Railroad (Italy), where both freight and passenger traffic are operated over a line sixty-six miles in length, traversing a very rugged country and in the winter exposed to severe climatic conditions. The equipment for the year ending July 1, 1904, comprised ten motor-cars and five seventy-ton locomotives. The service performed amounted to 61,934,569 ton-kilometres. The average annual mileage of motor-cars and locomotives amounted to 54,351 kilometres, while the steam locomotives superseded by electric equipment never exceeded an average of 29,000 kilometres.

The total cost of electrical and mechanical repairs to locomotives and motor-cars, for the year ending July, 1904, works out at 1.4 cents per locomotive or motor-car-mile.

Summarizing the foregoing we have the following:

	Tractive Effort 20 Per Cent Adhesion. Lbs.	Repairs of Electric Equipment of Equivalent Electric Locomotive. Estimated. Cents.	
Manhattan Railway	22,000	0.5	
Subway train	33,000	0.7	
Wilkes-Barre and Hazleton Railroad	17,000	0.38	(actual)
Lackawanna and Wyoming Valley Railroad	14,000	0.84	"
Niagara, Buffalo and Lockport Railroad	12,000	0.79	"
Rete Adriatica-Valtellina line Freight locomotives Passenger cars		1.6	Complete cost of maintenance of locomotives and cars.

The reports of the Interstate Commerce Commission do not show what proportion of the item, "Repairs and renewals of locomotives" is chargeable to renewals, but from inspection of detailed reports of our most important railway systems it seems fair to assume that in the case of the average railway from four per cent to five per cent of the total cost of repairs and renewals of locomotives represents the cost of renewals.

Taking into account all of the various considerations which must affect the conclusions in the general case, so far as we have been able to gather them, we are of the opinion that for equal draw-bar pull, the repairs and renewals of electric equipment of locomotives, assuming good design and construction according to present standards of the art, should not exceed one cent per locomotive-mile, and will probably approximate 0.9 cent per locomotive-mile.

Taking the higher figure, it is evident that the substitution of electric equipment for all parts of a steam locomotive other than frame, wheels, axles, cab, and other parts which are common both to electric and steam locomotive construction, a very great saving is effected. We have been unable to fix with satisfactory exactness a figure representing the average cost of repairs and renewals of these parts, but it would seem liberal to allow 1.5 cents per locomotive-mile, this being equivalent to an allowance of something over $400 per annum per locomotive. Taking this figure and adding the estimated costs of repairs and renewals of electric equipment, we have 2.5 cents per locomotive-mile as the estimated total cost of repairs and renewals of electric locomotives, performing the average work now done by steam locomotives.

In 1904 the aggregate revenue train-mileage operated was about 1,050,000,000. To cover locomotive mileage in switching, operating work-trains, and pushers we assume 1,300,000 locomotive-miles. In 1904 the aggregate repairs and renewals of locomotives was $105,633,752, the average cost per locomotive-mile, therefore, being 8.1 cents. A reduction to 2.5 cents, is equivalent to a saving of seventy per cent in the cost of this item, or 5.256 per cent of operating expenses, reducing this item to 2.253 per cent of total operating expenses under electric operation.

In the foregoing consideration of the item, repairs and renewals of locomotives, we have assumed equal locomotive mileage per day in steam and electric service. The item of expense under consideration will be proportional, approximately, to the mileage, and therefore we have made the comparison upon this basis. Nothing short of years of actual experience can establish definitely the ratio of electric to steam locomotives required in average service, but it seems reasonable to assume that this ratio will not exceed two to three and will probably approximate one to two.

Item 13. "Repairs and renewals of passenger cars." In cases where electric locomotives are substituted for steam locomotives, there should be some reduction in this item. Painting should be considerably reduced by reason of the elimination of smoke. The life of the up-

holstery and interior decoration of the car will be increased.

Item 14. "Repairs and renewals of freight cars." This item will be favorably and very materially affected if it should ever prove practicable to operate heavy freight trains by locomotives located at intervals throughout the trains and controlled by the multiple-unit system.

TABLE I—*Continued.*

Item	Amount 1905	Per cent. 1905	1904	1903	1902	1901	Average Five Years	Estimated Cost of operation by Electricity
Conducting Transportation	769,613,017	55.486	56.670	55.893	54.671	54.979	55.540	43.454
20. Superintendence	25,007,322	1.803	1.779	1.742	1.711	1.726	1.752	1.752
21. Engine- and round-house men	130,437,844	9.404	9.550	9.562	9.401	9.340	9.451	4.710
22. Fuel for locomotives	156,429,245	11.278	12.128	11.675	10.776	10.602	11.292	5.553
23. Water supply for locomotives	9,147,590	0.660	0.659	0.614	0.623	0.612	0.634	0.000
24. Oil, tallow, and waste for locomotives	5,442,970	0.392	0.397	0.389	0.366	0.361	0.381	0.250
25. Other supplies for locomotives	3,295,384	0.238	0.248	0.232	0.218	0.206	0.228	0.228
26. Train service	90,654,520	6.536	6.735	6.677	6.737	7.011	6.739	6.739
27. Train supplies and expenses	21,963,086	1.583	1.581	1.552	1.500	1.471	1.537	1.000
28 Switchmen, flagmen and watchmen	60,141,422	4.336	4.386	4.313	3.984	3.848	4.173	4.173
29. Telegraph expenses	24,823,266	1.790	1.788	1.754	1.784	1.785	1.780	2.000
30. Station service	89,304,658	6.438	6.605	6.664	6.832	6.947	6.697	6.697
31. Station supplies	8,961,573	0.646	0.686	0.667	0.676	0.672	0.669	0.669
32. Switching charges, balance	4,201,050	0.303	0.280	0.244	0.272	0.319	0.284	0.284
33 Car per diem and mileage, balance	18,835,325	1.358	1.358	1.400	1.480	1.618	1.423	1.423
34. Hire of equipment, balance	3,040,641	0.219	0.195	0.214	0.180	0.161	0.194	0.194
35. Loss and damage	19,782,692	1.426	1.279	1.094	0.990	0.819	1.112	0.750
36. Injuries to persons	16,034,727	1.156	1.196	1.120	1.048	0.911	1.086	1.000
37. Clearing wrecks	3,594,658	0.259	0.275	0.284	0.221	0.189	0.246	0.200
38. Operating marine equipment	9,903,479	0.714	0.696	0.745	0.721	0.862	0.748	0.748
39. Advertising	5,959,380	0.430	0.418	0.428	0.429	0.428	0.427	0.427
40. Outside agencies	19,688,261	1.419	1.411	1.449	1.579	1.615	1.495	1.495
41. Commissions	233,987	0.017	0.022	0.044	0.077	0.089	0.050	0.050
42. Stock yards and elevators	786,850	0.057	0.060	0.057	0.069	0.075	0.064	0.064
43. Rents of tracks, yards and terminals	23,947,881	1.727	1.563	1.544	1.519	1.724	1.615	1.615
44. Rents of building and other property	4,814,407	0.347	0.382	0.411	0.440	0.440	0.404	0.404
45. Stationery and printing	8,772,789	0.632	0.640	0.642	0.622	0.638	0.634	0.634
46. Other expenses	4,408,010	0.318	0.353	0.376	0.416	0.510	0.395	0.395

Assuming that the methods of train operation remain the same, the adoption of electricity will still effect a reduction in the cost of Item 14, and for two reasons, *viz.:*

1. The practical elimination of damage by fire which now frequently is superimposed upon damage caused by collision or derailment.

2. Reducing the wear and tear of wheels and brake equipment in descending long grades, by reason of the opportunity afforded to brake the trains by causing the motors to operate as generators.

No statistical data are available upon which to base an estimate of the probable reduction in this item to be expected from this cause. On comparatively level lines it will not be important, but on mountain-grade divisions it should operate to prevent a very large proportion not only of wear and tear directly due to grade but also of the destructive freight wrecks which are now so frequent. In the way of an estimate, nothing more definite than a guess based upon consideration of probabilities and the views of various operating officials, can be advanced; but in the opinion of the writers the general substitution of electricity for steam operation in freight service should reduce this item from 7.657 per cent to something like six per cent of operating expenses.

Item 15. "Repairs and renewals of work cars," will not be changed materially.

Item 16. "Repairs and renewals of marine equipment," obviously will not be changed.

Item 17. "Repairs and renewals of shop machinery and tools," will be reduced under electric operation since the repairs to locomotives will be radically decreased as shown and since the tool equipment required for the electrical machinery is materially less expensive and varied. It would seem reasonable to expect that this item would be reduced from 0.662 per cent to about 0.5 per cent of total operating expenses. Of course a large proportion of the shop machinery and tools are for car repairs.

Item 18. "Stationery and printing," will not be changed.

Item 19. "Other expenses." The classification of operating expenses includes under this item "all expenditures for account of electric light, torches and lamps used in machinery department, shops, roundhouses and offices and the oil and material for the same; the proportion of labor and material for the proper operation and repair of electric lights used in connection with other departments; wages of engineers and firemen and the cost of fuel and water in operation of stationary engines or boilers for supplying power and heat to shops, buildings and roundhouses."

Other factors comprised are comparatively small and it is evident that the ability to use electricity for light and power purposes in shops, roundhouses and offices produced at a works-cost of 0.6 cent and delivered to the point of consumption at a figure which on the average will approximate 0.75 cent will effect a material reduction in this item. We estimate that it will be reduced to about 0.4 cent.

CONDUCTING TRANSPORTATION.

Item 20. "Superintendence," will not be changed.

Item 21. "Engine and roundhouse men," includes in addition to the engine crew, roundhouse men whose work, of course, is chiefly in connection with the cleaning and maintenance of the engines. This item averages for the railroads of the United States 9.451 per cent of the operating expenses, of which ninety-one per cent, or about 8.6 per cent of the operating expenses, is for engine men and for firemen. Of this 8.6 approximately

5.5 per cent is for engine men and 3.1 per cent for firemen.

If we compare conditions which now exist upon such systems as the Manhattan Elevated with the conditions which existed before electricity was adopted, it seems reasonably clear that, with a competent motorman operating a controller which instantly cuts off power and applies the brakes in case the hand of the motorman is removed from the handle of the controller, the safety of trains and passengers is assured in higher degree than it was under the old condition. In case of injury to an engineer on trunk-line railways there would be some advantage in the presence of the fireman, owing to the fact that, if competent, he could operate the train to the next station. This point might be met by having the train conductor or brakeman or flagman qualified to operate the electric train to its destination in case of accident to the motorman. The degree of skill required, so far as actual manipulation of the mechanism is concerned, would be far less than in the case of the fireman who might in emergency be entrusted with the responsibility of operating the steam train.

It would seem that there can be no question of the reasonableness and safety of entrusting the operation of an electric locomotive to one man, provided the control system is equipped with effective appliances arranged to cut off the power and apply the brakes in case the motorman's hand leaves the handle of the controller.

The work required of the motorman operating an electric train is far less onerous and is performed under conditions much less severe than is the case with the locomotive engine-driver, nor is the motorman, in order effectively to perform his duties, required to serve years of apprenticeship during which he must become familiar with the complicated mechanism under his control and competent to make, upon the road, any ordinary repairs. The work required being relatively easy, the apprenticeship comparatively short, and the mechanical knowledge necessary greatly reduced, it is reasonable and proper that the compensation of the motorman, under average conditions, should be less than that of the engineman.

Apart from the attitude to be expected upon the part of employés, and aside from any question of sentiment, however, the management of a railway contemplating the substitution of electricity for steam would not be justified in lowering the standard so far as character and judgment are concerned, which are requisite for the motorman equally with the engineman. It must be remembered also that familiarity with the road and with signals, etc., is as important in his case as in that of his predecessor.

It is impossible, of course, to fix, with definiteness, a figure representing the wages of the motorman in railway service as compared with that of the engineman whom he may succeed, but it seems reasonable to assume that under average conditions the services of thoroughly competent motormen can be obtained at a figure which will represent a reduction of one per cent in operating expenses, making this item 4.5 per cent instead of 5.5 per cent.

The expenses for roundhouse men, which under steam operation is about 8.5 per cent, will be greatly reduced both by reason of the reduction in the number of locomotives required for a given service and also by reason of the demonstrated less cost of maintenance per locomotive-unit. It is entirely liberal to allow for this item one-fourth of its cost in steam operation, the saving here effected being equal to 0.64 per cent of the average operating expenses of steam railroads in the United States.

The estimated cost of the item under consideration, therefore, is 4.71 per cent of total operating expenses.

Item 22. "Fuel for locomotives." One of the marked economies resulting from the substitution of the electric motor for the steam locomotive in railway operation is in the reduction of the fuel account. The cost of fuel upon the average steam railway in the United States for the five years 1901 to 1905, inclusive, constituted 11.292 per cent of total operating expenses. The aggregate cost in 1905 was $156,429,245.

The following figures show comparative fuel consumption upon the Manhattan Elevated Railway during the year ending June 30, 1901, when steam locomotives were employed and during the year ending June 30, 1904, when electricity was used. During the period first mentioned one pound of coal produced 2.23 ton-miles, if the weight of the locomotive be included, and 1.5 ton-miles, if the weight of the cars only be considered.

During the latter period (electric traction) one pound of coal burned at the power-house produced 3.85 ton-miles, excluding weight of locomotives; therefore, the ratio of ton-mileage per pound of coal in favor of electric operation was 2.57 to one. Including weight of locomotive it was 1.72 to one.

The average speed under electric operation was approximately two miles an hour greater than that attained by steam, and if correction be made for this difference the ratio of ton-mileage per pound of coal excluding weight of locomotives is approximately three to one, and including locomotives two to one in favor of electric traction. It should be noted also that in this case the coal burned at the power-house was of lower grade, and therefore, less expensive than that used by the locomotives, and it is reasonable to expect that in general electric traction will mean utilization of cheaper fuel.

The advantage in favor of electric oper-

TABLE I—*Continued.*

Item	Amount 1905	Per cent. 1905	1904	1903	1902	1901	Average Five Years	Estimated Cost of operation by Electricity
General Expenses	55,022,127	3.965	3.844	3.789	3.947	4.120	3.933	3.933
47. Salaries of general officers	11,676,616	0.842	0.841	0.823	0.925	0.984	0.883	0.883
48. Salaries of clerks and attendants	18,582,142	1.340	1.313	1.254	1.244	1.262	1.283	1.283
49. General office expenses and supplies	3,459,470	0.249	0.230	0.234	0.249	0.257	0.244	0.244
50. Insurance	6,885,932	0.496	0.471	0.432	0.412	0.384	0.439	0.439
51. Law expenses	7,096,275	0.512	0.513	0.541	0.558	0.549	0.549	0.549
52. Stationery and printing (general expenses)	2,439,781	0.176	0.170	0.175	0.168	0.161	0.170	0.170
53. Other expenses	4,861,911	0.350	0.306	0.3330	0.391	0.447	0.365	0.365
Recapitulation of Expenses								
54. Maintenance of way and structures	274,415,279	19.784	19.519	21.185	22.255	22.272	21.003	22.354
55. Maintenance of equipment	288,012,604	20.765	19.967	19.133	19.127	18.629	19.524	12.287
56. Conducting transportation	769,613,017	55.486	56.670	55.893	54.671	54.979	55.540	43.454
57. General expenses	55,002,127	3.965	3.844	3.789	3.947	4.120	3.933	3.933
Grand Total	1,387,043,0	27100.	100.	100.	100.	100.	100.	82.028

ation is more marked if we assume that alternating-current equipment is to be used, as in general would be the case in the electrification of trunk lines or long divisions. In a particular case which we have worked out with great care, the trolley and track-rail losses average 3.9 per cent, the load-factor being 0.33. This is the result obtained in using the single-phase system for the equipment of a division approximately forty miles in length, the potential being 11,000 volts. The grand average of traffic in the United States does not exceed seven trains per day passing a given point in each direction, and the trolley and track-rail energy losses for this traffic would be less than two per cent.

Assuming that such a trolley voltage is used in connection with a feeder-potential of say 40,000 to 60,000 volts, the allowable loss in these feeders at maximum load certainly will not exceed ten per cent and the energy efficiency of step-up transformers, transmission feeders, and step-down transformers will be ninety-two per cent. Combining this figure with the energy efficiency of trolley and track, as above stated, the resultant efficiency from bus-bars of power-house to the train will be ninety per cent.

The works-cost of a kilowatt-hour at the bus-bars of the Manhattan plant is less than 0.6 cent when coal costs $3 per ton, this coal having a calorific value of 14,000 British thermal units per pound. This cost includes fuel, water, labor, maintenance, miscellaneous supplies, and in short everything except capital charges. Where fuel is less expensive, as in the Middle West, large modern plants, using steam turbines, are producing the average kilowatt-hour at a price not exceeding 0.5 cent exclusive of capital charges, and in at least one case at a works-cost approximating 0.4 cent.

As will be shown hereinafter, were all the railroads of the United States to be operated by electricity, the average plant required, assuming power to be transmitted 150 miles, would approximate 4,000 kilowatts if the plants supplied but a single line 300 miles in length. The great bulk of the total power supplied, however, would be derived from large plants in which the cost of producing the unit of energy, considering average costs of fuel and labor, should be less than 0.6 cent. While the small plants would exceed this figure, we believe that as a grand average 0.6 cent is ample to cover the case. Water powers and other sources of cheap power supply would tend to keep down the average cost of power under the assumed condition of electrification of the entire railroad system of the country.

In the case of the single-phase, twenty-five-cycle motor, assuming the average length of run for freight trains to be fifteen miles and for passenger trains twenty miles, we have calculated that of the energy delivered to the locomotive approximately eighty-six per cent will be effective for traction in the case of the passenger locomotive, which is gearless, and about eighty-four per cent in the case of the freight locomotive, which uses single reduction gear. Combining the two, it is safe to say that of the energy supplied at the bus-bars in the power-house not less than seventy-five per cent will be effective for traction in the average locomotive equipped with this apparatus.[1]

The cost of a kilowatt-hour effective for traction therefore is 0.8 cent and the cost of a horse-power-hour effective for traction about 0.6 cent, of which 0.35 cent is for fuel when coal of 14,000 British thermal units per pound costs $3 per ton of 2,240 pounds, and 0.25 cent is for other power-house supplies, power-house labor, and maintenance of power-house equipment.

(To be concluded.)

Meeting of Boston Section of Illuminating Engineering Society.

The Boston section of the Illuminating Engineering Society met at the American House, Boston, on January 15, with President Campbell in the chair. Mr. Cowles, of the Edison Electric Illuminating Company, gave a talk on "The Progress of Electrical Illumination," during which he gave a brief history of the early arc lamps, beginning with the Brush apparatus, and coming down through the carbon filament incandescents to the metal filament lamps and high efficiency arcs. He pointed out the attractive features of the tantalum and tungsten lamps, and also discussed the mercury lamp and the Moore vacuum tube.

Mr. Cowles was followed by J. S. Codman, whose subject was "Aids to Progress in Lighting." Mr. Codman rehearsed the difficulties that formerly beset an illuminating engineer, say six or seven years ago, he being obliged to do his work without any assistance such as he now receives in the shape of distribution curves which are now published in technical papers, etc., and also by calculation tables which save a vast amount of figuring in working out problems of lighting.

At the close of these talks, a general discussion followed, participated in by Professor Adams, Dr. Bell and Messrs. Campbell, Gifford, Clark, Hale, King and others.

Armature Laminations for Dynamos.

It was formerly the opinion that the softest Swedish charcoal iron was the most suitable material for armature laminations. About fourteen years ago attention was called to the phenomenon of aging, in virtue of which the hysteresis loss occurs when iron is subjected for long intervals to temperatures of sixty degrees centigrade and higher. The rate of deterioration through aging is generally most marked in soft Swedish charcoal iron, while it is low or altogether absent in certain qualities of sheet steel. Often the very cheapest qualities of sheet steel are the most suitable as regards freedom from aging. The permeability of such sheets is inferior to that of rolled sheets from charcoal iron, and the initial hysteresis loss may be somewhat higher, but these disadvantages are reduced by annealing from the highest temperature which it is practical to employ. H. M. Hobart here gives specifications for sheet steel which gives a low aging factor. The one which he prefers contains about 0.06 per cent carbon; 0.01 per cent silicon; 0.08 per cent phosphorus; 0.5 per cent manganese, and 0.03 per cent sulphur. Any sheet steel showing less of impurities than the foregoing will be acceptable so far as the aging feature is concerned. Armature cores are usually built from laminations one-half millimetre in thickness. Theoretically, sheets of different thickness should be employed in designs for various purposes, but commercial reasons justify the keeping of but a single standard. There are many cases where sheets much thicker than this could be employed with advantage, such as for the cores of rotors for induction motors. There is not much to be gained by the use of sheets of less thickness, for this entails a higher percentage of total thickness of insulating varnish, so that the percentage of lost space will be greater. The thinner the plate, moreover, the greater will be the percentage which the skin of inferior magnetic quality bears to the total thickness of the plate. Moreover, the price increases with decreasing thickness. Departures from this standard will be more often justified when made in order to employ thicker sheets than to employ thinner.—*Abstracted from the Mechanical Engineer (London), January 5.*

[1] For the motor curves upon which these figures are based, we are indebted to the courtesy of the Westinghouse Electric and Manufacturing Company.

The New Power Station of the People's Light, Heat and Power Company, Springfield, Ohio.

The rapid progress made within the last few years in the design and construction of light and power stations is aptly illustrated by the new power-house of the People's Light, Heat and Power Company, at Springfield, Ohio. The building is of fireproof construction and is well lighted and ventilated. The exterior is illustrated in Fig. 1, which shows the front end facing on West Jefferson street. A spur from the Pittsburg, Cincinnati, Chicago & St. Louis Railroad enters the building, providing a means for delivering coal on cars directly in the boiler room, which is illustrated in Fig. 2. Four Heine safety boilers of 450 horse-power each furnish steam at 150 pounds pressure to four Westinghouse automatic compound non-condensing engines of 400 horse-power each, with cylinders sixteen inches by twenty-seven inches and sixteen-inch stroke, and 257 revolutions per minute, which operate four Westinghouse 250-kilowatt, engine-type, revolving-field, two-phase, sixty-cycle, 2,200-volt generators, shown in Fig. 3.

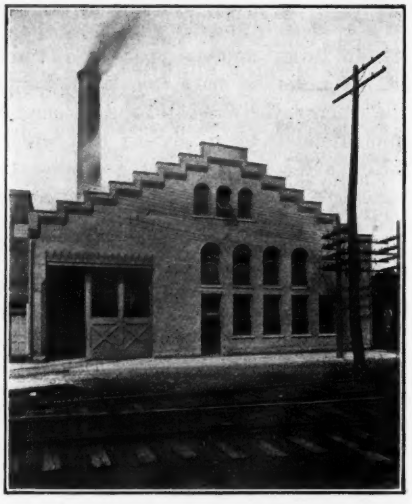
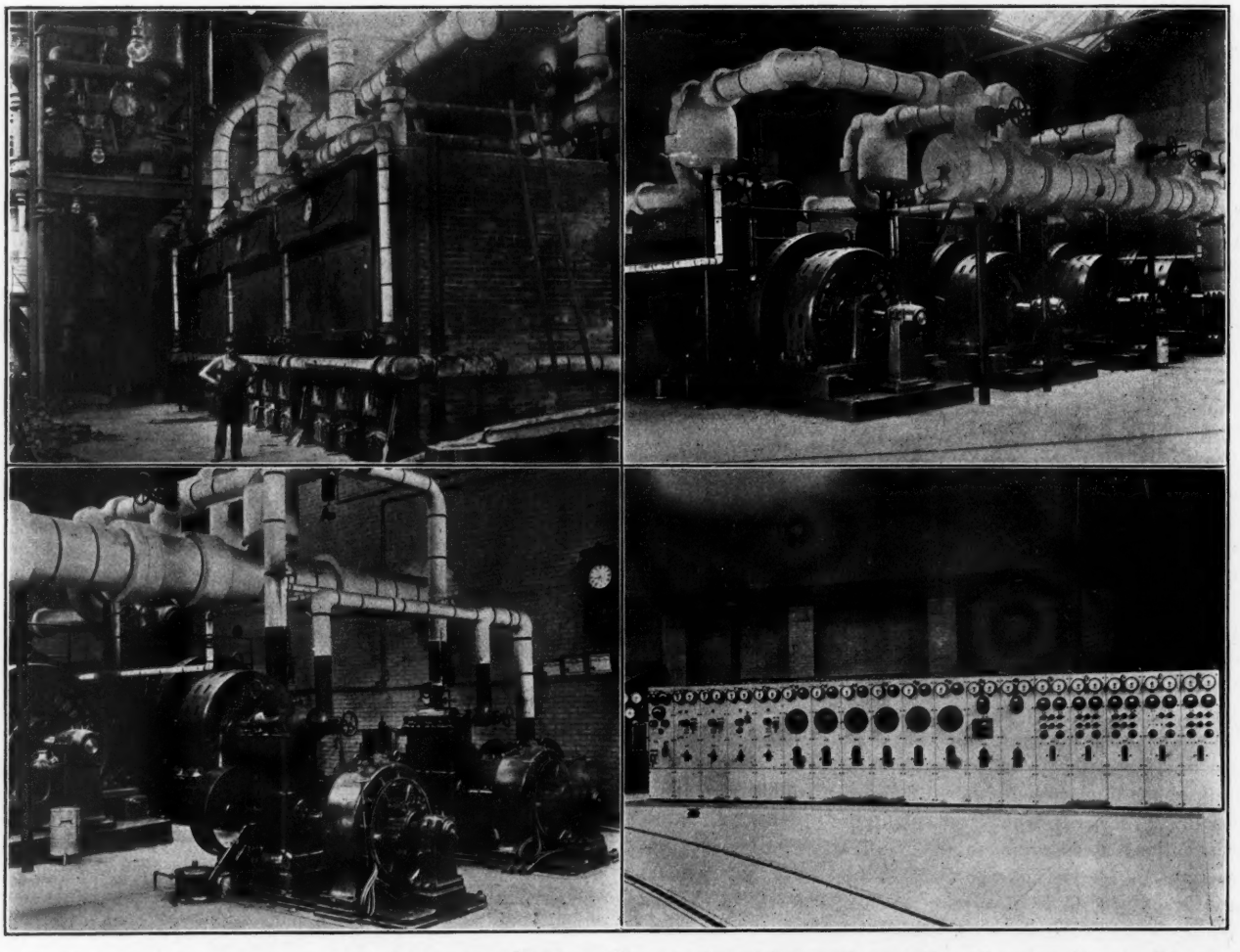


FIG. 1.—EXTERIOR VIEW OF POWER STATION, PEOPLE'S LIGHT, HEAT AND POWER COMPANY, SPRINGFIELD, OHIO.

Excitation is furnished by two twenty-five-kilowatt, 125-volt, direct-current Westinghouse generators direct connected to two Westinghouse Junior automatic engines of thirty-two horse-power each, with eight-inch by seven-inch cylinders. These units are illustrated in Fig. 4.

The switchboard shown in Fig. 5, which was furnished by the Westinghouse Electric and Manufacturing Company, is constructed of white Italian marble and consists of eighteen panels as follows: One double exciter panel on which is mounted one voltmeter, two ammeters, two field rheostats, two double-pole knife switches and a voltmeter plug; four generator panels provided with two ammeters, field switch, rheostat, type D oil switch and voltmeter receptacle; six feeder panels, on which are mounted an ammeter, single-phase integrating wattmeter, Stillwell regulator and type J oil circuit-breaker; two power panels, each provided with two ammeters, a polyphase integrating wattmeter and type F oil switch; four standard constant-current regulating transformer panels. A swinging bracket is provided on which are mounted two voltmeters and one synchroscope; this with a



PEOPLE'S LIGHT, HEAT AND POWER COMPANY, SPRINGFIELD, OHIO. FIG. 2.—BOILER ROOM. FIG. 3.—MAIN ENGINES. FIG. 4.—EXCITER ENGINES IN FOREGROUND. FIG. 5.—SWITCHBOARD.

Tirrill regulator completes the switchboard equipment.

Immediately behind the switchboard (Fig. 6) are located five Westinghouse 100-light, two-circuit, air-cooled constant-current regulating transformers, 2,200-volt primary, which furnish current for 378 Westinghouse series alternating-current arc lamps for street lighting, the Peoples' Light, Heat and Power Company having the contract for lighting the streets of the city.

The Westinghouse lamp is of new design throughout and contains many excellent features that materially affect its regulation, durability and convenience in handling. It has a differential control, the arrangement of the series and shunt windings and core giving close regulation from the beginning, with full length of carbons to the cutting out of the lamp with carbons exhausted. The binding posts, switch, cut-out gas check and adjustments have all received careful attention to obviate the faults found in so many lamps.

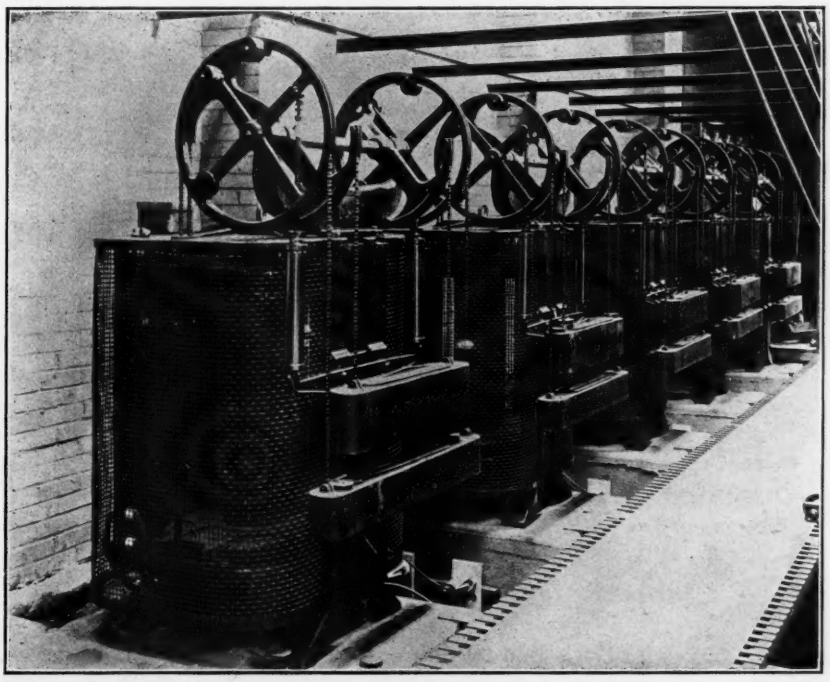


FIG. 6.—BANK OF FIVE ARC LAMP REGULATORS.

Figures 7 and 8 give two street scenes in Springfield, showing the manner in which the lamps are distributed.

Aside from the city lighting, this company does a large commercial business, furnishing current for Nernst, incandescent and multiple arc lamps and motors.

The entire equipment of the power-house is striking in its uniformity, which is a great contrast to the older stations where many different types of machines are generally found, each performing its particular work.

Terrestrial Magnetism.

Two important reports have been issued by Dr. L. A. Bauer, chief of the division of terrestrial magnetism of the United States Coast and Geodetic Survey, Washington, D. C. These are designated as appendices 3 and 4 to the report on terrestrial magnetism for 1906. Appendix No. 3 gives the results of magnetic observations made by the survey between July 1, 1905 and June 30, 1906. The report includes the results of observations made in the United States and in the outlying territories during this period. There are five magnetic observatories in continuous operation, while observations were made in 358 localities. A number of observations were made at sea also by the several vessels employed by the survey. Several of the instruments employed in the work have been studied carefully, and some of them have been discarded as unsatisfactory. It is the aim to reduce the error of observation to less than two minutes in making determinations of declination and dip, and to determine the horizontal intensity within one part in a thousand. The reduced results of the measurements are given in this appendix, together with a detailed description of the various observation stations.

Appendix No. 4 is entitled "Distribution of the Magnetic Declinations in the United States, January 1, 1905." It gives a discussion of the work, and contains a large isogonic chart for the United States, and tables of secular changes. The large number of new, reliable and well-established determinations for magnetic elements made by the survey chiefly within the past seven years has made it possible to undertake the construction of new magnetic maps for the United States with an accuracy hitherto not attainable. The first of these maps is the one contained in the present report. Others covering the outlying territory will be issued subsequently. The present chart depends upon accurate observations made at 3,500 points distributed over the United States. A new feature of the present chart is the extension of the isogonic lines over the oceanic areas embraced by it. These extensions rest upon available recent sea observations made by the Coast and Geodetic Survey, the United States Navy and the British Navy.

FIG. 7.—ARC LAMP SUSPENSION IN CITY, PEOPLE'S LIGHT, HEAT AND POWER COMPANY, SPRINGFIELD, OHIO.

A striking feature of the present chart is a large number of twists and turns and peculiar features exhibited by the isogonic lines over the land. In this respect the chart represents more of these sinuosities and irregularities than any hitherto is-

FIG. 8.—ARC LAMP SUSPENSION IN SUBURBS, PEOPLE'S LIGHT, HEAT AND POWER COMPANY, SPRINGFIELD, OHIO.

sued for this country. It was thought that these offer a sufficient proof that the present chart gives a more accurate representation of the actual facts of nature than any heretofore made, and these sinuosities are to be considered normal features of the land. If more observations were available the twists and turns would doubtless be more marked. Flowing curves usually indicate that observations are too few, and no dependence can be placed upon them. By examination of the isogonic lines it is seen that there are a number of interesting correspondences between the twists and turns of the lines and well-known physiographic features, such as coast lines, mountain ranges, rivers, etc. These correspondences have been noted in previous charts, but they stand out much more clearly in the present one. The magnetic survey of the United States, as far as completed, embraces, on the average for the entire country, one station at which the three magnetic elements have been reliably determined for an area of 900 square miles, or thirty miles square. For one reason or another certain sections of the country have more stations in proportion to the area, and others less. The work which has been done has made it possible to construct, in addition to the chart presented in this report, other charts showing the declination, dip and intensity, based upon practically the same stations —that is to say, upon homogeneous data. The mathematical analysis of all the results of the work will be more fruitful than has been possible hitherto. Future magnetic survey work will consist in the multiplication of stations in regions where the number falls considerably short of the average given above and in disturbing regions, and also of well-selected stations for watching the secular changes.

The lines giving the location of points where the annual change for 1905 was equal to show that the amount varies over the entire country from zero to four minutes. A note on the chart states that the north end of the compass is moving to the westward for places east of the line of no change, and to the westward for places west of it at an annual rate indicated by the lines of equal annual change. Three regions are thus distinguished. The region in the United States east of the agonic line or line of no magnetic declination, where the declination is increasing from about two minutes to four minutes per annum. The region between the line of no declination and the line of no annual change, which two lines are practically parallel. In this region the declination is decreasing at a rate varying from nothing to two minutes per annum. To the west of the line of no change the declination is east throughout, and is increasing at a rate varying from nothing to four minutes. The study of the isogonic lines and the lines of equal annual change seem to indicate that the magnetic pole during the past twenty years has moved chiefly southward, as the west component of motion is greatly subordinated to the southerly one.

Owing to the large amount of new data available it became necessary to revise the tables of secular change which were issued with the report for 1902. An exhaustive recompilation of all available reliable data for the entire country was undertaken, so that that now presented possesses a completeness which no previous report had. Tables are given for each state and territory, which show the change in declination from 1750 to the present time, enabling the declination at any past date to be determined.

National Electric Light Association Offices.

The National Electric Light Association, which for years past has occupied offices in the Electrical Exchange Building, 136 Liberty street, New York city, has moved into the new Engineering Societies' Building. Of late years the association has rapidly outgrown its old offices, and has therefore been prompt to avail itself of the facilities presented in the new home for engineering provided through the generosity of Mr. Carnegie. It occupies four handsome and commodious rooms on the eighth floor of the building on West Thirty-ninth street. The suite consists of four rooms, namely, main office, secretary's office, board room and library, and storeroom. Each room is appropriately furnished for its specific functions and the association will henceforward enjoy accommodations worthy of its growing influence and prestige.

LETTERS TO THE EDITOR.

"Some Points on Illuminating Engineering for the Small Central Station."

To the Editor of the Electrical Review:

A printer's error in the paper which I read before the last Northwestern Electrical Association Convention on "Some Points on Illuminating Engineering for the Small Central Station," made me say one thing which I never intended to say, and which has unfortunately, but quite naturally, been incorporated in your abstract which appears on page 149 of your January 26 issue. By this error I am made to appear as condemning art glass domes. What I wished to condemn was not the art glass dome but the method of arranging lights in these domes which is most common. The common arrangement is a cluster of lamps at various angles, which is both inefficient and inartistic. One lamp pointed straight down inside the dome, equipped with a proper translucent reflector, will both illuminate the dining-room table better and the dome itself more uniformly and hence more artistically.

J. R. Cravath.

Chicago, January 29.

Term for Wireless Message.

The remark was made in the Electrical Review a short time ago that although the adoption of the term "radio-telegraphy" by the International Conference on Wireless Telegraphy gave a much needed name to the new system, we still are without a satisfactory short designation for the messages sent by this method. This remark has elicited the following comment from Dr. Achilles Rose, of New York city:

"Radio-telegraphy = actino telegraphy (*ἀκτινοτηλεγραφία*).

"Actino telegram=actino-telegraphema (*ἀκτινοτηλεγράφημα*).

"No expert word-maker is required. Every Greek knows these words. Telegram can not be said; this would be nonsense; it would mean 'a far line' and even then incorrect. Every small boy, in fact everybody in Greece, says *τηλεγράφημα*, a writing into distance."

Name for the Wireless Message.

To the Editor of the Electrical Review:

Allow me to suggest "radogram," corresponding as it does with telegram and cablegram.

E. H. Markinson.

Chicago, Ill., January 23.

Small Electric Tree-Felling Outfit Wanted.

To the Editor of the Electrical Review:

Being desirous of ordering a small electric outfit for cutting down trees of tropical hard wood, and cross cutting same, we beg you to send us catalogues, list of prices and estimates for an outfit of about four horse-power.

P. Nanton & Company.

25 Rue Roux,
Port Au Prince, Haiti.
January 29.

Electrical Notes from Europe.

(By Our Special Correspondent.)

AT the Paris Automobile Show there was observed an electric device for starting up the motor of an automobile which seemed to have considerable merit. A number of mechanical devices for the same purpose have been invented, but the electric method has some advantages over these. It is designed to start the gasolene motor of the car withoutobliging the driver to make use of a hand-crank, and he therefore does not need to leave his seat, as is usually the case when the motor is to be set running. Mounted on the chassis at one side of the motor is a compactly built dynamo of small size, in fact not much larger than the magneto, which it replaces. It is geared to the motor shaft by a ten to one reduction gearing, so that it runs at a much higher speed than the motor. On the road the gasolene motor sets the dynamo running and the current is used to charge a small storage battery which consists of a few cells which can be stored conveniently on the car. Supposing the motor to be stopped, it is easy to start it by making the dynamo run on the battery current as a motor, and the gasolene motor is brought up to speed. A simple lever operates the whole, so that the device is a great convenience. Besides, the dynamo affords a supply of current which can be used to light the car, especially the interior, which is a decided advantage, and as already remarked it gives the current for the motor ignition and thus replaces the magneto, so that there is but little additional expense or weight.

The Ducretet firm, of Paris, are bringing out a new type of electrolytic current converter which is designed to be used on alternating-current mains so as to secure direct current therefrom. It was also exhibited at the Automobile Show. The new converter, designed by De Faria, is claimed to be much superior to anything which has previously been made in this line. Its action is based on a property of aluminum discovered by Buff in 1857 and brought to notice again by Ducretet in 1875, after which Pollak and others took up the question. The following phenomena are observed: When we pass a current in an electrolytic cell whose electrodes are one in aluminum and a second of lead, we find that the current circulates easily when the aluminium electrode is cathode (negative pole) and on the contrary the current is interrupted when the aluminum is the anode (positive pole). A layer of alumina is instantly formed in this case which opposes a very high resistance to the passage of the current. De Faria applies this principle in his new cell with especial reference to overcoming the drawbacks inherent in its use, namely, polarization and heating, and he also desired to increase the efficiency and make it independent of the temperature. The characteristic of his system is the use of a small rod of aluminum which is placed near the bottom and inside a cylinder of lead forming the second electrode. By means of holes in the latter cylinder the liquid keeps up a good circulation which prevents clogging up and gives the cell a long life. The lead contains some antimony in its composition. It is easy to remove and replace the aluminum piece when it is used up, but it lasts a considerable time in any case. The main use of the device is for charging storage cells from alternating-current mains, and there are naturally many other uses where direct current is necessary.

An interesting exhibit was that of the Compagnie des Gaz Comprimés, showing their method of cutting sheet iron by an oxygen and coal gas blowpipe. The specially designed apparatus which is a modification of the oxyhydrogen blowpipe, gives a very high heat and a small pointed flame. Thick pieces of metal can be cut by the flame, seeing that at a sufficiently high temperature iron becomes as combustible in oxygen as carbon itself. A jet of oxygen sent upon a piece of iron or steel which has been previously raised to a white heat causes it to burn with so much energy that the metal melts like water and is sent off in a shower of brilliant sparks. This is an interesting experiment, as well as a useful operation, seeing that we can cut very quickly even thick pieces of metal. Sheet iron four inches thick is cut in a few minutes and the cut is almost as clean as if made by a saw, with a great gain in speed. The blowpipe is designed to work with oxygen and illuminating gas, the latter replacing hydrogen at a much less expense, and is designed to assure the initial heating of the piece to a white heat, then to keep heated the jet of oxygen so as to increase the surety and the energy of its action. There are two concentric jets in the blowpipe, an outer jet of oxygen having gas mixed with it so as to give a combustion at a very high temperature, also a central jet which is turned on only when the metal is brought to the right heat, being formed of oxygen under a regulated pressure, using a higher pressure for the larger pieces of metal. Such an apparatus is likely to prove of great service in metal working, as it saves a great deal of time in cutting heavy pieces of metal. By properly directing the flame the cut can take any desired path, and a circular piece is cut out of two-inch sheet metal in a few minutes.

The use of windmills for operating small dynamos is a question which is receiving some attention in Germany, and several firms have gone into the manufacture of windmills specially adapted for the purpose. Braun & Company, of Dresden, are now building what is known as the "Herkules" type, and the wheel has a maximum diameter of twenty-seven feet. In order to run the dynamo from the wheel shaft under the proper conditions, it is connected with the latter by a belt and the pulleys are so arranged that should the wind wheel turn at too great a speed owing to a high wind, the belt will slip upon the shaft and there will be no danger of the dynamo running too high. This answers very well for the unusual cases, while for ordinary use there is a speed governor which acts to regulate the dynamo speed within the proper limits. An automatic device is also used in connection with the battery of accumulators which is generally placed on the circuit of the dynamo. When the speed of the wind falls too low, say below twelve feet per second, the battery is cut out of the circuit so as to prevent it from discharging into the dynamo. A characteristic plant of this kind is erected on the domain of Holzen, in the valley of the Isar, and it gives enough current to operate all the agricultural machines used on the different farms; also pumps and various machines, and supplies the lighting current for the property. The Herkules windmill plant is also used in a large varnish factory in Germany at Nerchau, and the dynamo furnishes the lighting current besides giving enough for running all the motors of the factory. Another plant is located at the large domain of Obertopfstadt and the current is used for agricul-

tural machines of various kinds, water pumps and for lighting.

Steam turbines have been recently erected in two of the large electric stations of Berlin, namely, the Oberspree and the Moabit plants, and they are now running very successfully. In the Moabit station there were formerly installed two 1,000-kilowatt turbines, furnished by the Allgemeine Elektricitäts Gesellschaft, but later on these were replaced by three larger sets, furnished by the same company, and rated at 3,000 kilowatts, while the outfit was further increased by the addition of two other units built by the Brown-Boveri firm, these having a capacity of 5,000 kilowatts each. As regards the 3,000-kilowatt groups first mentioned, they are direct-coupled to three-phase alternators, which supply current at 10,000 volts, running at 1,500 revolutions per minute. The Brown-Boveri turbines are rated at 7,500 horse-power, and are coupled to 10,500-volt alternators working at fifty cycles. In these turbines the steam pressure at the maximum is 12.5 atmospheres. Underneath, in the cellar, is placed a surface condenser for each group, and the turbine pumps used for the water circulation, as well as the air pumps, are direct-coupled and run by three-phase motors of fifty and 150 horse-power sizes. These motors take current from a 500-volt circuit. It is stated that the steam consumption for these turbines is 6.6 kilogrammes per kilowatt-hour when working on the full load of 5,000 kilowatts, and eight kilogrammes when running upon 2,500 kilowatts.

A new form of screen for receiving the X-rays has been brought out recently by the Buchler firm, of Germany, and it is intended to replace the platino-cyanide of barium screen to advantage, seeing that it not only gives a better impression of the rays, but costs considerably less. Sulphide of zinc, specially prepared, is used for coating the screen, and it glows where the image of the rays falls upon it. In this respect it gives a bright image of the X-rays, and what is a great advantage is that the phosphorescence of the zinc sulphide makes the image last for some time after the rays have ceased to fall upon it, and it may last for five minutes supposing the rays to have been applied during one minute. All residual effects of the X-rays can be suppressed, however, and the screen made perfectly clear for another impression, by applying a certain amount of heat, and for this an incandescent lamp serves very well. As the price of the new screen is only one-fourth of the platino-cyanide screen, it seems to have the advantage in all points over the latter.

Various alloys used in metallurgical work are now manufactured in Europe on a commercial scale by the electric furnace process. Among these is ferro-silicon, which contains from fifty to ninety per cent silicon. In foundry work it is used for deoxidizing steel, and also enters into the composition of spring steel, besides having many other applications. The annual consumption of ferro-silicon is stated to be 27,000 tons. Ferro-chromium is another alloy to be produced by the electric furnace, with about sixty-five per cent chromium and from ten down to one per cent carbon. It is used for armor plate, projectiles, tools, etc., and the annual production is about 7,000 tons. Silico-manganese is an alloy which is intended to replace ferro-manganese and is coming into use. A new alloy is also formed with silicon, manganese and aluminum. Tungsten powder for use with special steels is replaced to advantage by ferro-tungsten, which is formed by treating wolframite in the electric furnace. C. L. DURAND.

Paris, January 26.

Steel Smelting by Electricity.

United States Consul Charles N. Daniels reports that the corporation of the city of Sheffield, England, recently conducted a three weeks' exhibition for the purpose of giving greater publicity to the electrical supply department, which is a municipally owned and managed department of the city.

Among the many electrical devices there exhibited was a small model of the Grongal Kjellin induction furnace. This particular furnace was built to melt platinum, but during the exhibition was daily used to produce small ingots of steel, and at the close of the exhibition was taken to the National Physical Laboratory at London. On December 3 a member of the Kjellin company lectured before the Sheffield Society of Engineers and Metallurgists at the department of applied science, University of Sheffield, upon the subject of steel making in electric induction furnaces.

Having pointed out that the furnace is simply an induction melting furnace, the lecturer gave a brief technical description of the Kjellin furnace. Currents are induced in a magnetic field by means of the primary circuit, maintained by an alternating current of high frequency, and this arrangement forms and maintains by induction a secondary circuit in the molten charge itself, disposed as this is in an annular crucible around the magnetic field. There are various modifications of the arrangement of the primary circuit and magnetic field in the different types of furnace, but the principle is the same in all induction apparatus.

The lecturer said that the frequently made assertion that the furnace, or, indeed, any type of electric furnace, could produce high-grade crucible steel from inferior material, or even direct from iron ore, and that in consequence the crucible process was doomed, is most misleading. It was true that impurities could be reduced, to a certain extent, in this furnace by adding "physic," and that rusty scrap iron could be properly reduced.

It was also true that high-class iron ore could be reduced to pig iron by means of the induction furnace, but it must be clearly understood that for such work power must be so cheap that the process could only be carried out successfully in localities where power was to be had for next to nothing; at least the present state of the art had not proved a commercial success. The furnace was only a modified crucible furnace; high-grade raw material must now, as heretofore, be used to produce high-class steel. It was not commercially possible to make high-class steel from inferior material; then, too, the difference in price between superior and ordinary raw material, as compared with the price of the final product, made this point one of minor importance.

What the induction furnace would do was to permit of larger cast, a cheaper and cleaner form of melting, and reduced cost of labor. The demand for big crucible quality ingots was increasing day by day. Die ingots ranged up to two tons weight, and the quality of steel must be perfectly regular and sound. Crank shafts and axles for motor cars necessitated the use of heavy crucible ingots. With few exceptions the crucible steel makers were confronted with really practical difficulties in making large ingots.

The induction furnace solves this problem for them, for it is as easy to make a two-ton charge in such a furnace as a sixty-pound charge in a crucible. The saving in cost was easily demonstrated. Most steel makers agreed that the cost of melting one ton of crucible steel was from $34.07 to $38.93. In the induction furnace it required 800 to 850 kilowatt-hours to a ton of steel and the cost in Sheffield would be from $9.73 to $10.34 per ton. Two men and one boy would be able to run a furnace turning out four tons in twenty-four hours, so that the cost for labor should not exceed $1.82 per ton.

The cost of lining, including repairs,

should not exceed fifty-one cents per ton; consequently the actual cost for melting one ton of steel should be well under $14.60; but if the cost was to run as high as fifty per cent of the cost of melting in crucibles the induction furnace had a great claim for the consideration of steel melters.

In addition to its freedom from injurious gases, which made it an exceptionally clean melting machine, the advantages to the men working it were considerable. There was no lifting of heavy crucibles, and tapping was easily done by tilting the furnace. The lining was not easily destroyed, and with small repairs would last from seven to eight weeks.

With regard to quality the steel made at Gysinge, Sweden, has been proved to equal the best tool steel, but the quality naturally depended upon the skill of the metallurgist and the purity of the raw materials used. There was no reason whatever to doubt that the best crucible steel could be made with the induction furnace, unless it was proved that the impurities acquired by the steel melted in coke or gas heated crucibles improved the quality of steel made in these crucibles.

Tungsten and chrome steels, as well as other steel alloys, could easily be made, and nickel steel had also been successfully turned out. Several furnaces of this type had already been erected in different parts of the world. At Gysinge, Sweden, a 175-kilowatt furnace had been in successful operation for the past five years, and two others were being constructed at Guldsmedhythan. In Germany two furnaces were being operated and three were being constructed, two of which would require 750 kilowatts. In Switzerland a 450-kilowatt furnace was now being worked, while another of 200 kilowatts was soon to be started in Spain. In England a furnace of 200 kilowatts was now at work and others were in course of construction.

A considerable part of each charge, about one-third, must be left in the furnace so as not to break the ring. In originally starting the furnace it was customary to pour in some molten scrap. The higher the resistance the better the furnace would work. Brass had been successfully dealt with in the Kjellin furnace, and no doubt nickel could be very economically treated by its use; there is no difficulty in melting even copper.

Manganese steel had been dealt with without trouble caused by its magnetic nonpermeability. Accidental failures of the current, if not prolonged beyond three or four hours, would not spoil a charge in the making. It had been proved feasible to make high steel with the furnace by placing charcoal in the crucible along with the metallic charge.

ANALYSIS OF ALTERNATING-CURRENT WAVES.[1]

BY L. A. HAZELTINE.

The methods described below were devised for treating electric waves graphically. The objects were the resolution of a wave into its harmonics and the determination of the effective voltage and current and the mean power directly from the wave-forms. In this treatment the waves are supposed given, as is usual, in rectangular coordinates, abscissas representing time and ordinates representing instantaneous values of voltage or current, as the case may be. Time is expressed in angular measure, so as to be independent of the frequency of alternation, one period being expressed by 2π. For the sake of simplicity, reference is had only to the usual alternating waves of like positive and negative portions. It is well known that such a wave may always be assumed to consist of the sum of a series of harmonic or sine waves, whose frequencies are odd multiples of that of the wave itself. Analytically it is expressed by Fourier's series in the form,

$$p = \Sigma\, p_n \cos n\,(x - r_n) \quad . \quad . \quad . \quad (1)$$

in which p is the ordinate of the irregular wave, and $p_n \cos n\,(x - r_n)$ is the ordinate of the nth harmonic, to the common abscissa x, measured in radians. p_n is called the amplitude and r_n the phase of the nth harmonic. An equivalent form is

$$p = \Sigma p'_n \sin nx + \Sigma p''_n \cos nx \quad . \quad (2)$$

in which $p'_n \sin nx$ and $p''_n \cos nx$ are respectively the ordinates of the sine and the cosine component of the nth harmonic. The constants in the two expressions are connected by the equations,

$$p_n^2 = p'^2_n + p''^2_n \quad . \quad . \quad . \quad . \quad (3)$$

and

$$\tan nr_n = p'_n\, p''_n \quad . \quad . \quad . \quad . \quad (4)$$

The complete proof of the principles on which all exact methods of harmonic analysis depend may be found in any treatise on that subject, and a brief outline only is given here. It may be shown that the mean product over a complete cycle of two harmonic variables is zero, except when they are of the same period. In that case it is equal to half the product of the amplitude of one with the amplitude of that component of the other in phase with it. Considering any wave to be the sum of harmonic waves, the mean product of the successive ordinates of this wave with those of a unit sine wave of n times the frequency, will consist of a series of terms, each expressing the product of the unit sine wave with one of the harmonics. The value of all these terms is zero, except that containing the nth harmonic. Since the amplitude of the sine wave is unity, this term is equal to half the amplitude of the component of the nth harmonic in phase with it, and this is also the value of the complete mean product. Thus, if by any means the successive ordinates of a wave can be multiplied by the sines and cosines of multiples of their abscissas and the mean values of the products found, the amplitudes of the component harmonics are determined and from them, by equations (3) and (4), the amplitudes and phases of the complete harmonics.

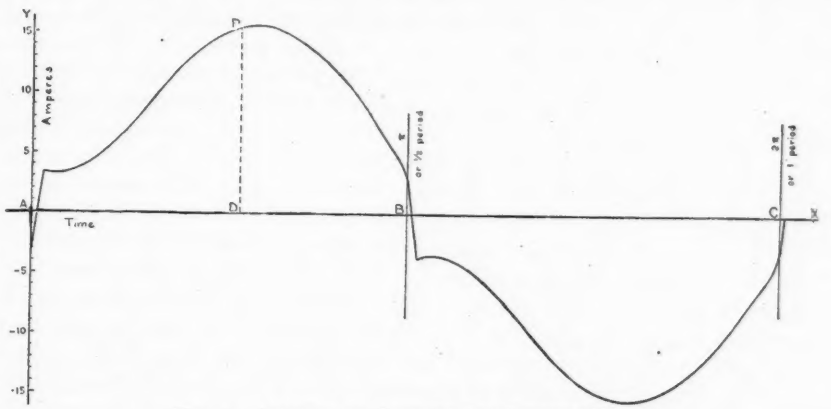


FIG. 1.—ANALYSIS OF ALTERNATING-CURRENT WAVES.

The novelty in the following method consists in the manner in which these multiplications are performed graphically and the products so arranged that their mean values can be readily obtained. Suppose, for instance, it be required to find the third harmonic of the wave shown in Fig. 1. Construct the curve of Fig. 2 from it as follows: Take any point P whose coordinates are $x = \text{AD}$ and $p = \text{PD}$; from a pole O lay off the radius vector $\text{OP}_1 = \text{PD}$, making an angle $\text{X}_1\,\text{OP}_1$ with the initial line which is $n = 3$ times AD. The curve thus obtained repeats itself every half period, which is

[1] Reprinted from *Stevens Institute Indicator*.

completed in $\frac{1}{2}\,n = \frac{1}{2}$ revolutions about the pole. Referring the curve to the rectangular axes OY_1 and OX_1, the ordinate $P_1D_1 = p \sin nx$ and the abscissa $OD_1 = p \cos nx$. From this polar curve two new rectangular curves are laid off having for abscissas the x of the original rectangular curve and for ordinates respectively the corresponding ordinates and abscissas of the polar curve. These curves are shown in Figs. 3 and 4, in which $A'D' = A''D'' = AD$, $P'D' = P_1D_1$ and $P''D'' = OD_1$; the second half periods are not needed as they are identical with the first. The mean heights of these waves are then determined, which may be readily done by means of a planimeter. As has been shown, these values are the half amplitudes of the components of the required third harmonic and from them the amplitude and phase of the complete third harmonic is readily calculated.

In practice it is most convenient to

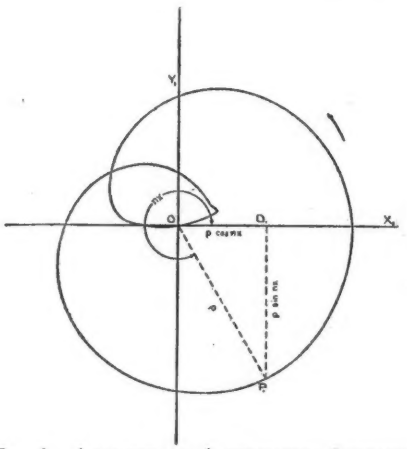


FIG. 2.—ANALYSIS OF ALTERNATING-CURRENT WAVES.

plot the curves of Figs. 3 and 4 on the same sheet with that of Fig. 2, the first about OX_1 and the second about OY_1 as axes of abscissas. Points on the rectangular curves are then obtained by simply projecting points of the polar curve to their proper abscissas, which, if rectangular coordinate paper is used, requires no other instrument than a pencil.

With slight modification this method can be extended to analyze other than alternating waves, such as pulsating or intermittent waves, in which a mean height term and even harmonics enter. This was done by Mr. George Crisson and the writer in their graduating thesis. For the alternating wave already shown the analysis was carried to the twenty-third harmonic. The correctness and accuracy was proved by the agreement of the sums of the harmonics with the original waves. The advantages of the method are its simplicity and its rapidity compared with the exact arithmetical methods. The analysis for each harmonic is independent of all the others, so that possible errors do not accumulate; and any accidental error is readily noticed from a periodic discrepancy in the fitting of the sum of the harmonics with the original wave.

In the theory of alternating currents,

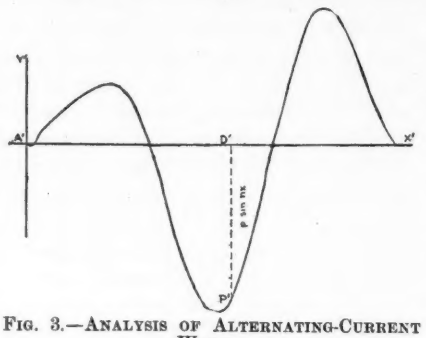


FIG. 3.—ANALYSIS OF ALTERNATING-CURRENT WAVES.

the effective value of a current or voltage wave is defined as the square root of the mean square of the instantaneous values. In like manner the power indicated by a current and a voltage wave is defined as the mean product of contemporaneous values of current and voltage. The ordinary method for obtaining these quantities from the wave-forms is by an actual squaring or multiplying of ordinates of the waves and averaging the results. There is, however, a method for finding a mean square graphically, which is as follows: Referring to the alternating wave already considered, lay off the polar curve II′ of Fig. 5 as would be done in obtaining the first harmonic, making the radius $OI = i$, say, the ordinate of the wave, and the angle $XOI = x$, the corresponding abscissa, measured in radians. The area of the polar curve thus drawn is, by the

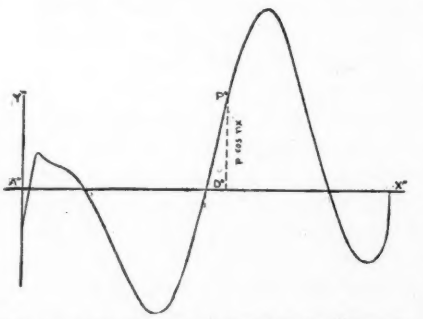


FIG. 4.—ANALYSIS OF ALTERNATING-CURRENT WAVES.

familiar formula, $\int_o^\pi \frac{1}{2}\, i^2\, dx$. But the effective value of the current as defined is expressed by the formula $\sqrt{\int_o^\pi \frac{i^2\, dx}{\pi}}$. Hence this effective value is given by multiplying the area of the curve by $\frac{2}{\pi}$ and extracting the square root.

This principle has been extended to determine the mean power indicated by a voltage with a current wave. Plotting on the same diagram of Fig. 5 the curve of impressed voltage EE′, which in this case is a simple harmonic wave, and letting $OE = e$, the ordinate of this voltage wave, we have as before, for the area, the expression $\int_o^\pi \frac{1}{2}\, e^2\, dx$. From these two curves, we obtain the difference curve DD′ by making its radius $OD = EI = e - i$, the difference between corresponding radii of the voltage and the current curves. Its area is similarly expressed by the formula $\int_o^\pi \frac{1}{2}\,(e-i)^2\, dx$. If now we take the sum of the areas of the first two curves and subtract that of the difference curve, the result is expressed as

$$\int_o^\pi \tfrac{1}{2}\, e^2\, dx + \int_o^\pi \tfrac{1}{2}\, i^2\, dx - \int_o^\pi \tfrac{1}{2}\,(e-i)^2\, dx = \int_o^\pi ei\, dx,$$

expanding the last term and uniting.

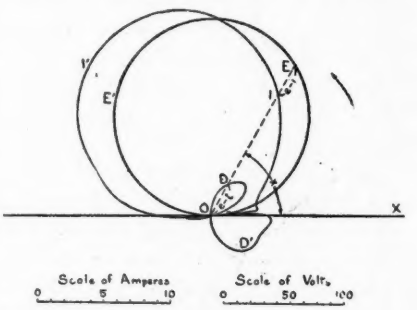


FIG. 5.—ANALYSIS OF ALTERNATING-CURRENT WAVES.

But the expression for mean power as defined is $\int_o^\pi \frac{ei\, dx}{\pi}$. Hence this mean power is given by dividing the combined area by π.

If the three areas be obtained separately, the effective voltage and current as well as the mean power may be found. The value of the effective voltage, as found in terms of whatever linear unit has been used, is reduced to volts by multiplying it by a constant equal to the number of volts represented by that linear unit, according to the scale used. The value of the effective current is similarly reduced to amperes. To reduce the power to watts, the constant used is one-half the product of these constants, if the areas have each been multiplied by $\frac{2}{\pi}$ in the first place. This method was also employed in the thesis mentioned above and gave results agreeing well with those derived from the harmonic analysis.

Electrical Notes from Great Britain.

(By Our British Correspondent.)

THE British Westinghouse Electric & Manufacturing Company, Limited, held its seventh annual meeting in London on Monday, January 14, when the directors submitted their statement for the year ended July, 1906. The trading profit for that period amounted to £7,568. The company's experience has been an unfortunate one from a shareholder's point of view, practically from the start, and it has been plainly seen for some time past that some drastic measure would soon have to be taken to put things on a sounder basis. Proposals with this object in view were approved at the meeting, and the capital is now to be reduced by £1,375,000, by writing off £2 per share from 500,000 preference shares and £5 per share from 75,000 ordinary shares. The possible rates of dividend, however, are to be increased from six per cent to ten per cent on the preference and from six per cent to twelve per cent on the ordinary shares. Of this reduction the sum of £1,083,817 will be devoted to writing down patents, good will, works and equipment, etc., and £291,183 will be devoted to the extinction of the suspense account, which represents money expended in past years in experimental development. The reasons which have made this drastic action necessary are stated thus:

(1) Because, owing to the development of the home electrical trade having been much slower than was anticipated, the scale of the Trafford Park works has so far proved to be too large; (2) because since the works were designed in the late nineties, there have been considerable changes in conditions of manufacture arising out of changes in types of apparatus; the steam turbine is here particularly alluded to. Though the home trade has been bad, there is a rapid growth recorded in the company's foreign and colonial business, which is now equal to one-third of the total volume. After negotiation with the American company a rearrangement has been made concerning foreign trading, under which the British company now has the right to do business in South America, and the American Westinghouse company receives the right to trade in various British colonies.

Further meetings have been held with a view to putting the South Wales Power Distribution Company on a surer footing. It is stated by those who have investigated the position of the undertaking, that some hundreds of thousands of pounds sterling have been lost, that there has been unfortunate management, and that consulting engineers' estimates of the probable early extent of the development were altogether too optimistic. To save what remained, it was stated by C. H. Merz, who has lately been called in to guide technically, that £500,000 must be found. This it was ascertained would be forthcoming if the large colliery owners and other power users in the area of the company would guarantee to take 40,000 horse-power. Unfortunately this guarantee has not yet been obtained; only 14,387 horse-power has been actually agreed upon. Furthermore, some of the collieries which now use the company's power are withdrawing their custom and proceeding to put down their own installations.

It has been evident for some time past that there are large numbers of English electrical engineers who do not regard the Institution of Electrical Engineers as affording them sufficient facility for social intercourse with one another. To many the hearing a paper read and discussed has been a lesser attraction than the opportunity to spend ten minutes or so in the coffee room handshaking and chatting with friends. A mild sort of agitation is proceeding at the moment with a view of providing more of these social facilities, and a movement is also on foot for organizing an electric club in London.

The National Electrical Manufacturers' Association at its last meeting gave brief consideration to the question of another electrical exhibition. No action will, however, be taken until the association further considers the matter in March. Its members are pledged not to support any big exhibition of the kind for the present unless started under association auspices.

The success of the 1905 show at Olympia will not soon be forgotten, and it is believed that there is a sufficient eagerness for another to justify the association in taking up the idea in earnest when it next meets. The last show was so successful because it combined both the popular and the technical elements. No doubt the next will be on somewhat similar lines, but with the addition of some of the bigger electrical plant manufacturing firms who were rather conspicuous by their absence in 1905.

A number of municipalities owning electricity supply systems have lately come to the conclusion that the time has arrived for investigating very closely the exact position of these undertakings. Woolwich and Islington are two cases where such an inquiry has been proceeding, and now an attempt has been made to inquire into the state of the Shoreditch system; all are in the London district, and probably the desire expressed by the public for "municipal reform" is responsible for this activity. In the case of Woolwich, Sir Alexander Kennedy was called in to advise, and he has stated in his report that reorganization of the undertaking is imperative, but that even then it will be years before it can be made remunerative. There are two fully equipped stations in the borough, but he says that with very little alteration one of them could be made quite sufficient for all the energy output required. The staff is stated to be too large, and, financially, things are quite unsound, for nothing has been set aside for depreciation. Further, there is a bank overdraft of some £29,000, and, in view of all the facts, Sir Alexander has strongly advised the council to see whether it would not be better for it to take a bulk supply from a big company owning a generating station at Greenwich, rather than to incur additional capital expenditure. The inquiry into the financial position of the Islington system is just about to take place and permission has been given for expert advice to be obtained. In the meantime a big scheme for an extension of arc lighting in the streets has been suspended.

We recently referred to the fact that a series of tramway accidents had led the board learned that two of the tramway mendations bearing upon the question of tramcar braking appliances. As the board learned that two of the tramway associations (the Municipal Tramway Association and the Light Railways & Tramways Association) were appointing committees to deal with the matter it has suggested that the two committees shall act together and that a representative of the

board should sit with them. This has now been agreed to and the joint committee will fully investigate the whole subject of tramcar brakes, sanding arrangements, etc. Another point in which some interest has been shown by the Board of Trade relates to the practice adopted in some localities with regard to the provision of lifting jacks at points on tramway routes. The Light Railways Association has informed the board that while it would be undesirable to make a regulation ordering all tramcars to carry lifting jacks, as some have suggested, yet it is desirable that provision should be made therefor at depots and elsewhere if practicable.

The last two meetings of the London body of the Institution of Electrical Engineers have been the most interesting and profitable held for some time past. Mr. James Swinburne's paper on the "New Incandescent Lamps" was summarized by the author in his own inimitable style at the meeting on January 10, before a goodly audience, and the discussion was opened by Dr. Harker and continued by Prof. S. P. Thompson. It was resumed at a meeting held on the following Thursday, January 17, when the proceedings were of equal interest. This paper is abstracted in this issue.

The question of standardizing carbon filament glow lamps has formed the subject of a great deal of discussion for several years past. It was referred to the sub-committee on Physical Standards of the Engineering Standards Committee in June, 1905. At the commencement of their labors particulars were obtained from the lamp manufacturers as to the tests with which they were able to comply. A conference followed and a draught specification was drawn up as a basis for discussion. Considerable amendment had subsequently to be made, and after all these deliberations the committee has now issued the final specification as agreed upon. This, at the request of the manufacturers, will not come into general use until July next. Among other definitions contained in this important document are the following: The useful life of a carbon filament glow lamp is to be the time taken for the mean horizontal candle-power (measured in units) of the lamp to drop twenty per cent from its standard value when run under standard conditions. The efficiency of a lamp is defined as the number of watts per mean horizontal candle-power which the lamp dissipates. The standard candle-powers for use with standard pressures of 110 and 220 volts are eight, twelve, sixteen, twenty-five and thirty-two mean horizontal candle-power. There are to be two classes of standard lamps, having a useful life of approximately 400 and 800 hours, respectively. All British standard lamps will be marked distinctly on the bulb with: name or trademark of maker; standard mean horizontal candle-power; voltage and reference letter A in a circle, to denote a 400-hour, fifty-watt lamp, and with the letter D in a circle to denote an 800-hour, sixty-six-watt lamp. The specification sets out the conditions which have to be observed in conducting the test of a consignment of lamps, also inspection tests for mechanical defects, insulation and vacuum tests, also tests for initial candle-power efficiency and total watts, and tests of useful life. The candle-power curves during life tests of lamps are to be such that the average mean horizontal candle-power during life test does not drop to a value less than ninety per cent of their standard candle-power, otherwise the entire batch from which the lamps are selected will be liable to rejection. A table of standard rating and limits, and a sketch of limit gauges for testing lamp cap dimensions, are in the document.

ALBERT H. BRIDGE.

London, January 18.

The Faraday Society.

The twenty-fifth ordinary meeting of the Faraday Society was held on Tuesday, January 15, 1907, at the Institution of Electrical Engineers, 92 Victoria street, London, S. W. Sir Joseph Swan, past-president, was in the chair.

E. E. Fournier d'Albe read a paper and opened a general discussion on "The Application of the Electron Theory to Electrolysis."

The electron theory by postulating the existence of material carriers of all electric charges, is practically an extension of the ionic theory to solids and gases, and it thus brings into line the processes of metallic and electrolytic conduction. In both cases the conductivity of a body is defined by the number of ions (in the wide sense) it contains in unit volume and by their average mobility; in a centimetre-cube of copper, for example, a current is conveyed by some four hundred trillion free electrons; in a centimetre-cube of milli-normal hydrochloric acid the current is conveyed by some two trillion hydrogen and chlorine ions. In a one-millimetre copper wire carrying one ampere the electrons will move at about one centimetre per second.

It is not yet clearly understood why free electrons should be observed in a vacuum and a metal, but that there should be none in a liquid. It is supposed, however, that it is the close packing of the metallic atoms which renders possible a frequent exchange of electrons between one atom and another, and while free the electron is able to fall along the potential gradient and thus constitute a current. In an insulator the electrons are effectively bound up with the atoms or molecular groups; in an electrolyte mobile charged groups are formed, which can follow the electromotive force. Free electrons are not formed on account of the unequal attractions for these displayed by the positive and negative atoms of the solute. Thus in an HCl solution, when two atoms of a molecule separate, the hydrogen atom will lose an electron and become positively charged, while the chlorine atom will gain one and become negatively charged. These ions will act as condensation nuclei, gathering molecules of the solvent around them and becoming "hydrated." The expenditure of energy involved facilitates the condensation, which explains the low mobility of the ions and the variability of the same, the drop of potential at the electrodes, and the liberation of uncharged products. The electromotive force is unable to drive the hydrated ions into the closely packed atoms of the electrodes, but if it exceeds a certain minimum it is able to drive electrons in or out, as the case may be, and the constituent elements of the ions then lose their condensing powers, drop the water molecules, and are thus liberated as uncharged atoms.

The author draws attention to the importance of making further studies of mobility and quantitative determinations of the hydration of ions as a preliminary for determining the sizes of the ions and of their actual constitutions based on kinetic principles. It is possible that the motions of heavy ions may be actually observed in an ultra-microscope. The future development of electrolytic theory will lie, in the author's opinion, in the direction of statistical analysis of these motions of the ions through the electrolyte and into the electrodes, after the fashion of Thomson's "counting experiment," and in the complete determination of the energy transformations at each stage.

John G. A. Rhodin considered that the electron theory, like the atomic theory, merely complicated matters, and was unnecessary. The conception of infinite divisibility was a necessary one in physics as in mathematics, if our reason was to be satisfied. Both in chemistry and physics we know of mathematical relations

only, and hypothesis are only crude images. The ether and electrons were invented because certain phenomena could be the more easily treated mathematically by means of these conceptions. A simple theory of ions was all that was necessary for understanding electrolysis; more hypotheses were not wanted. Existing theories left many well-known facts without explanation. He suggested the appointment of an International Committee for generalizing existing theories and making them available to the average intelligence.

Dr. H. Borns asked whether the Hall effect and the recent experiments of Kaufmann did not throw some doubt on the electron theory. Why were there no free electrons in liquids?

Dr. J. A. Harker was not clear as to whether the theory supposed atoms to be composed entirely of electrons or whether there were a central nucleus. If the former, one would expect more intermediate formations. He thought the fundamental conceptions of the theory should be made perfectly clear, so that the explanations of various phenomena given by it could be deduced from some simple postulates.

Dr. T. M. Lowry pointed out that much of the work on hydration asked for by the author had been carried out, among others, by Biltz, Jones and Bousfield. The latter had shown, for example, that the chlorine ion attached five water molecules to itself.

N. T. M. Wilsmore considered that the theory which looked upon electrons as exerting a sort of osmotic pressure at the surface of an electrode, conceived admirably the mechanism of electrode potential and of electrode reactions. It was noteworthy that the more electro-positive a metal, the more easily it threw off electrons under the stimulus of ultra-violet light, for example. He showed how the theory explained, in a simple manner, oxidation and reduction phenomena and the action on the positive accumulator plate. He thought that the negative electron should have a distinctive name, and proposed using the word "negatron," which had been suggested.

F. Kaye remarked on the simple explanation of the different mobilities and, therefore, hydrations of the various ions on the view that the positive and negative ions acted to different degrees as condensation nuclei. He asked whether, when a liquid was evaporated, there was a movement of electrons into the vapor.

F. S. Spiers pointed out that the theory did not seem to help in explaining the fundamental preliminary to electrolysis, namely, dissociation in solution.

E. E. Fournier d'Albe replied to the various speakers. He did not think that the few considerations put forward by Mr. Rhodin overthrew the theory. The difficulty of the Hall effect mentioned by Dr. Borns was more serious, but the negative swing that had been observed might be due to positive ions of great mobility, and not necessarily to the existence of positive electrons. A similar recent observation of the Faraday effect could be similarly explained. Kaufmann's experiments dealt with structure of electrons and merely pointed to Abraham's theory of a rigid electron being more probable than Lorentz's, which, in order to account for the Michelson-Morley experiments, supposed the electron to become shortened in its passage through the ether. Their great mobility in face of little resistance would prevent free electrons existing in liquids. When a metal was liquefied, probably polymerization took place, and ions were formed which carried the current.

In reply to Dr. Harker, it seemed that atoms most likely consisted of negative electrons whirling round a positive nucleus. The solar system presented a close analogy. Only certain configurations would be stable, hence every intermediate stage of element would not persist. The theory at present could not be built up from simple postulates; it was in the induction stage, and kept in close contact with facts.

In reply to Mr. Kaye, electrons did not pass into the vapor from a boiling liquid; the surface of the liquid was a perfect semi-permeable membrane.

The chairman, in moving a vote of thanks to the author for his important and interesting paper, which had stood so well the trying ordeal of some trenchant criticism, referred to the inadequacy of the old ideas to account completely for all the phenomena of conduction, electrolytic and other, ideas which he, none the less, found it not easy to get rid of, without at least some further consideration.

The Zircon-Wolfram Metallic Filament Lamp.

After the reading of a paper on "New Incandescent Lamps," by James Swinburne, at a meeting of the Institution of Electrical Engineers of Great Britain, held January 10, much interest, says the *Electrician*, London, was taken in the exhibition of a metallic filament lamp, known as the Zircon-Wolfram lamp, suitable for pressures of 200 to 220 volts, as hitherto it has been impossible to get a metallic filament lamp suitable for high pressures.

It appears that this lamp is the invention of Dr. Zernig, of Berlin, who has been working at the subject for some years. The filament was originally made of zirconia mixed with carbon. This gave a high efficiency filament, but only suitable for low pressures. Subsequently tungsten was introduced. As to the exact process used, it is difficult to obtain any exact information, but it appears that it depends upon utilizing hydrogenous combinations of metals. Nitrogenous combinations have also been used, but they are less suitable, as higher temperatures have to be used in the chemical operations. Hydrogenous combinations seem to have been first used by Winckler, but only to a slight extent. The material that is obtained is in such a form that the filaments can be made by a process of squirting, which, of course, is a very great advantage, as it is probably owing to this that low candle-power lamps can be made. Lamps are at present made for sixteen candles on 100 volts, or thirty-two candles on 200 volts.

The introduction of tungsten into this particular lamp has enabled an extraordinarily rapid advance to be made in the pressure at which it will run. Thus, although the pressure was only thirty-seven volts rather more than a year ago, this pressure has now been raised to 220 volts. The advantage in being able to adhere to the simple squirting process is seen not only in low candle-power but also in the cost of manufacture, which is said not to exceed that of the manufacture of carbon filament lamps by more than one pence (two cents) per lamp. This, of course, does not mean that these lamps will be put upon the market at practically the same price as the carbon lamp, but it is proposed to sell them at two shillings six pence to three shillings (sixty to seventy-five cents) each, which can not be regarded as excessive for a high-efficiency lamp.

As to the results obtained, the lamp has been found to run equally well on alternating as on direct current. It is not fragile, and the efficiency is about 1.2 watts per candle. Early tests on thirty-seven-volt lamps at the National Physical Laboratory gave excellent results. According to a test carried out by the Westminster Electrical Testing Laboratories in the spring of last year, the efficiency of a 115-volt thirty-five-candle-power lamp varied from 1.75 at the start to 2.24 at the end of 1,000 hours; but the report of a later test, carried out on the Continent at the end of last year, on some 200-volt sixty-five-candle-power lamps, showed a considerable improvement on this, the efficiency being about 1.38 watts per candle at the start, and about 1.28 after 500 hours.

For the purpose of investigating the merits of this lamp the Zircon Synd. (Ltd.), of 24, Budge-row, E. C., London, has been formed.

REVIEWS OF CURRENT ENGINEERING AND SCIENTIFIC LITERATURE

The Calculation of Single and Polyphase Windings by Means of a Vector Diagram of Field Strength.

It is shown here by H. Görges analytically that a diagram representing the field induction of an alternator at any instant may be obtained by means of a simple graphical construction. Supposing the machine to be a three-phase alternator with a certain number of coils per phase per pole, these coils will be uniformly distributed and their joint effect may be obtained by adding together at any instant the induction due to each coil. To do this graphically, construct a hexagon and mark off the sides so as to represent each coil. Draw radii from the centre to these points; then at any instant the magnetomotive force, and therefore the induction, of each coil will be represented by the projection of the corresponding radius upon the vertical. In this way the well-known step-formed induction diagrams are constructed, representing the various phases through which the induction wave passes. Having these waves it is easy to calculate the electromotive force generated at any instant.—*Translated and abstracted from Elektrotechnische Zeitschrift* (*Berlin*), *January* 3.

Regulating Device for Dynamos.

A description is given here of a new device for regulating the voltage of alternators, which has been brought out by Charles A. Parsons and Alexander H. Law, of England. The device consists of a laminated ring of iron placed between the pole-pieces and surrounding the armature. This ring is wound with two coils connected together, the coils being placed between the pole tips. An alternating current is sent through the coils, which has the effect of varying the reluctance of the magnetic path through the ring. In ordinary operation the ring may be placed either on the generator or on the exciter. The alternating current sent through it may be drawn from a series transformer, the primary winding being connected in the leads from the alternator. Under light loads the alternating current passed through the coils surrounding the regulating ring is small, the reluctance of this leakage path is comparatively small, so that a considerable portion of the main flux will leak from pole to pole by this path. As the load increases, the current through the regulating coil increases. More of this leakage flux is forced to pass into the armature, thus increasing the inductance and raising the voltage. If the ring be placed upon the exciter the effect is the same, except that in this case changes in load on the alternator produce corresponding changes in the voltage of the exciter, and thus in the main exciting current. It has been found that where such a device is applied to the exciter magnet the inductive loss of voltage in the winding around the leakage path is comparatively small; while if applied to the main magnets it is rather great. If there are several alternators running in parallel, suitable equalizing wires may be fitted between the respective regulating coils, so as to produce the same compounding of all.—*Abstracted from the Mechanical Engineer* (*London*), *January* 12.

The Use of Equalizing Batteries in Three-Phase Installations.

A description is given here of a small battery installation used for balancing the load on a small three-phase power system. The load on this system varied considerably, so that although the mean was only thirty kilowatts, it was necessary to run a 100-kilowatt generator to take care of the periods of maximum load. To avoid this necessity a 650-ampere-hour storage battery was installed, consisting of 120 cells. To charge the battery a three-phase synchronous motor, coupled directly to a direct-current generator and a three-phase synchronous converter, is connected to the supply lines. This motor maintains the running speed of the charging group constant. The synchronous converter is supplied with alternating current from the secondaries of a three-phase series transformer, so that the current flowing in through the slip rings is proportional to the load on the system. The charging generator is a shunt-wound machine having a separately excited coil supplied with direct current drawn from the direct-current side of the synchronous converter. This coil acts in opposition to the shunt coil. The effect is to lower the voltage of the direct-current machine as the load on the supply system increases. At a certain point it begins to run as a motor, driving the synchronous motor as a generator and supplying power to the line. As the load decreases the reverse operation takes place. In order to control the apparatus the field of the rotary converter is mounted so that it may be displaced by hand through an angle of twenty-two and one-half degrees. This enables the angular position of the fields of the synchronous converter and the synchronous motor to be adjusted so as to obtain the best conditions for operation. The rotary runs well without sparking. The entire equipment is said to give satisfactory results.—*Translated and abstracted from L'Industrie Électrique* (*Paris*), *January* 10.

The Design of Small Motors for Manufacture in Large Quantities.

The principles of designing small motors are given briefly here by H. M. Hobart, who then takes up the considerations which should be borne in mind when these motors are to be manufactured in quantities. After having decided upon suitable designing constants it is well to select a certain number of graded diameters for the armatures, each with two or three different core lengths. A certain number of magnet cores of varying cross-sections are also standardized. The commutators are designed with reference to the current to be collected in each case. Several standard diameters and lengths should be chosen. With these standard parts the designers may work out suitable ratings, using various combinations of armatures, fields and commutators, so as to cover a wide range in output. For example, if the smallest armature core—ten inches in diameter and four inches long—be run at a speed of 400 revolutions per minute, it will give two and one-half horse-power; with a core twenty inches in diameter and fifteen inches long 180 horse-power may be obtained. Between these limits practically all sizes can be made with but three additional diameters. Such a plan lends itself to a high degree of standardization, and has the important merit of giving its natural ratings to a design of any given diameter and core length. It brings the commutat-

ing and thermal limits into harmony, and generally leads to obtaining a considerably greater output for a given total shop cost than is otherwise obtainable. It facilitates quick deliveries and confers the ability to supply any size called for without obtaining special designs. When adopted it is necessary to select the different punchings with the greatest care. The same is true of the size of the slots. This plan, while suitable for manufacturing on a very large scale, is also practicable for small manufacturers, where it is of more importance to make a maximum use of a minimum number of standard parts. The author points out that the general drift of practice in design during the last few years has been toward decreasing weight of the apparatus, but there is still a wide margin left for further improvement. Some useful tables and curves are given for facilitating the design of the machines discussed.—*Abstracted from Electrical Engineering (London), January* 10.

The Production of Radium from Actinium.

It was suggested a short while ago by Dr. B. B. Boltwood that actinium might be an intermediate product in the formation of radium from uranium. This suggestion is critically examined here by Dr. E. Rutherford, who has been interested in that particular question for some years. In 1904 he obtained some of Giesel's actinium which he dissolved in acid, and removed the greater part of the radium by precipitating barium in the solution. The solution was then watched with the idea of detecting an increase in the content of radium but without success. After Dr. Boltwood's announcement, the solution was examined again for radium, but, unfortunately, became contaminated, thus vitiating the result. However, part of the original supply of actinium remained, and this was carefully tested. It was found that the radium in it had increased at least four times since it had been originally laid aside. The former failure is thought to have been due to the chemical treatment adopted. A more careful method has been used, employing the contaminated solution referred to above, and in this way it has been found that there is a progressive increase in the amount of radium, amounting to eighty per cent of the initial value over a period of five weeks. If this rate of growth continues the amount of radium in the solution at the end of a year should be more than eight times the initial value. An important point in this matter is the possibility that the growth of radium observed in the actinium solution is not due to the actinium itself, but to another distinct substance normally separated from the radioactive material with the actinium. To throw some light on this question Dr. Rutherford compared the rate of production of radium observed in his actinium with the rate to be expected on the simple theory of supposing actinium to be transformed directly into radium. It was found that the growth of radium agreed with the disintegration theory if the period of half transformation of radium is about 2,600 years. This period is not very different from that found by Boltwood from quite distinct considerations. This is satisfactory as far as it goes, but such an agreement between the periods obtained by the two methods implies that the activity due to the actinium in pitchblende is about the same as that due to radium and its products. This, however, was not found to be the case by Boltwood, so that there is here an anomaly remaining to be explained. Rutherford has also found that radium arises from the active deposits of actinium, but the growth was much smaller than was to be expected from theoretical considerations. The conclusion he reaches is that there is no doubt that the immediate parent of radium is present in actinium, separated from pitchblende; but it remains to be proved whether this is actinium itself or some other substance.—*Abstracted from Nature (London), January* 17.

The Direct-Reading Cymometer.

An instrument designated as a "cymometer" has been devised by Dr. J. A. Fleming for measuring the wave-lengths of electrical waves. It consists of a sliding tube condenser joined in series with a variable inductance. The two elements are so connected that one movement of a handle varies simultaneously and in the same proportion the capacity of the condenser and the inductance of the coil. The circuit of the condenser and the inductance is completed by a thick copper rod, which forms what is known as a closed oscillatory circuit, the capacity and inductance of which can be varied simultaneously and in the same proportion over certain limits. When such a circuit is placed in contiguity to another circuit—for example, the antenna of a wireless telegraph transmitter—in which high-frequency oscillations exist, these last tend to induce in the cymometer secondary electrical oscillations; but the amplitude of these secondary oscillations is extremely small, unless the circuit of the cymometer is tuned or adjusted to the primary circuit in which the oscillations are taking place. When this adjustment is exactly made the primary oscillations create secondary oscillations of great amplitude—in other words, set up a powerful secondary current in the cymometer circuit. This adjustment is effected simply by moving the handle in and out. The proper adjustment is determined by means of a neon vacuum tube connected between the inner and outer surfaces of the sliding tube condenser. Neon is one of the rare gases contained in the atmosphere, and it has been found that a tube filled with rarefied neon constitutes an extremely sensitive means of detecting high-frequency electrical oscillations, as the tube glows with a brilliant orange light when the platinum terminals are connected to two points on the circuit in which such oscillations are taking place. The cymometer, in convenient form, covers only a comparatively short range, so that for wide variations a number of such instruments are necessary. A scale mounted on the instrument enables the wave-length and the frequency and the constants of the instrument to be read off directly.—*Abstracted from the Electrician (London), January* 11.

General Electric Company Meeting.

The local office engineers of the General Electric Company from the principal cities in the United States gathered in annual session at the company's main office in Schenectady, N. Y., January 21 to 26 inclusive. The synopsis of the discussions covered in detail the work during the year. Friday afternoon, January 25, about forty of the engineers left the city in a special car for New York where they attended the first regular monthly meeting of the American Institute of Electrical Engineers in the new Engineering building. Friday night the party continued on its way to Lynn, Mass., where the Lynn plant was inspected. Among the local office engineers in the New York-Lynn party were C. T. Mossman, Boston; J. H. Lighthipe, San Francisco; James Lyman, Chicago; L. F. Demming, Philadelphia; William H. Hand, St. Louis; H. V. D. Allen, Atlanta; W. S. Culver, Cincinnati; W. G. Whitmore, New York, and L. Wilson, Denver.

Methods of Getting New Business

A DEPARTMENT DEVOTED to the COMMERCIAL DEVELOPMENT of CENTRAL STATIONS

Managers are Invited to Contribute Suggestions for Methods of Increasing the Demand for Electric Service

EDITED BY CHARLES A. PARKER.

The Value of a Display Room.

Of all the cogs which go to make up a new-business wheel, perhaps none is more important than is an efficient and sufficient display room.

You would not consider that a dry goods merchant would do a very thriving business who was content to keep his wares under cover and who had his store fitted up in such a way that nothing was visible to the eyes either of the passer-by or the person who entered the store.

It lies at the very foundation of business that it is the goods themselves which attract the buyer.

Exhibit of the Chattanooga Electric Company, Chattanooga, Tenn., in connection with Pure Food Show.

There may be some isolated exceptions where it is not necessary to show the goods, but these are few and far between, and electricity certainly is not one of them, because electricity. is peculiarly a thing which people require educating upon.

What is electricity?

With all your technical knowledge you are at a disadvantage in answering that question.

People know what water is, they know what gas is, but there are very few who pretend to know what electricity is.

All the more reason then why you should make an attempt to show them what electricity will do, since that is the nearest you can get to telling the people what it is.

A well-ordered display room should be, if possible, on one of the main thoroughfares, preferably on one of the best corners of the main thoroughfare in your city.

It should be large enough, roomy enough and attractive enough to maintain an exhibit of all the special applications of electric current in the three great fields of light, heat and power.

Even if you do not make a practice or do not wish to make a practice of selling various devices which the public must buy to secure these special applications of electricity, it is essential to have a quantity of such material on hand for exhibition and demonstration purposes.

Remember that the great mass of the public is like a child.

It learns things as children learn them, by having practical object lessons placed before its eyes, by becoming acquainted through actual observation.

But there is a crying need for the central station display room, not only because the public requires educating as to what electricity is, and what it will do, but because there is actually a very strong and general prejudice against electricity on the part of the public, a prejudice founded on the fear of thunder and lightning, on the unfortunate amount of publicity given to such subjects as "Electrocution at Sing Sing," etc., and this prejudice or fear must be removed if electricity is to enjoy the full and complete confidence of the people, which we, being more fully acquainted with electricity, know that it deserves to command.

The opening of a display room, such as we have recommended, would become one of the most potent factors in dispelling from the public mind the idea that electricity is unsafe, uncertain or dangerous.

It becomes also the very strongest element in backing up your soliciting department and your advertising campaign.

If you set forth, for instance, in your advertising bulletin, folder, or booklet the marked superiorities of the electric flat-iron over any other kind of flat-iron, that will, of itself, arouse considerable curiosity, which must, however, remain unsatisfied unless there is some sensible and practical way of showing the public these same superiorities in actual use.

Let us take a single case as an illustration.

Here is Mrs. Smith, who has become interested in the electric flat-iron through your monthly bulletin, we will say.

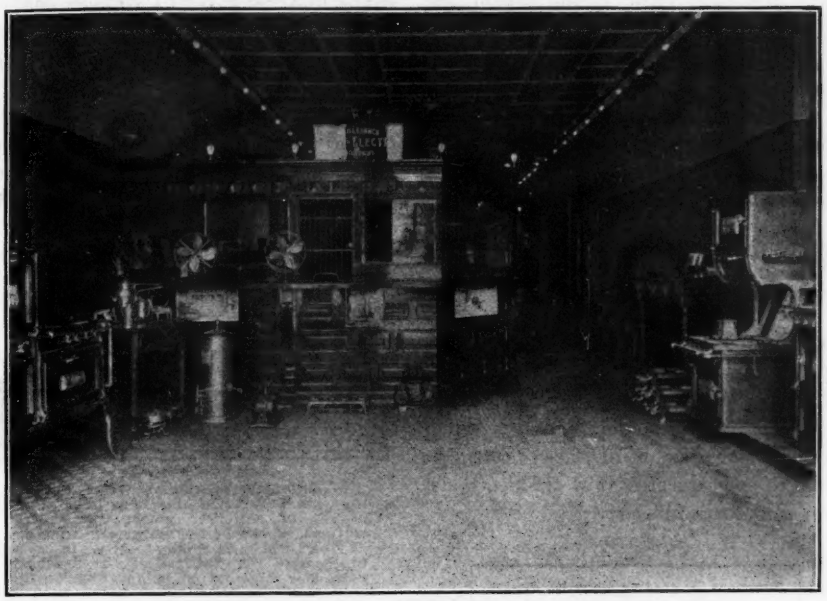
She sends you a card or telephones you to have a solicitor call.

He does so and goes fully into the matter with her, explaining just how the iron may be connected to the ordinary lighting socket, how little it costs per month to do ironing the electric way, etc.

But still Mrs. Smith is not convinced. It is when she sees the electric flat-iron actually doing business that she is overcome with a burning desire to possess an an electric flat-iron, and it is the display room which in many cases will be responsible for her conversion to electricity for

ironing and perhaps to many other usages in the home.

There are display rooms and display rooms.

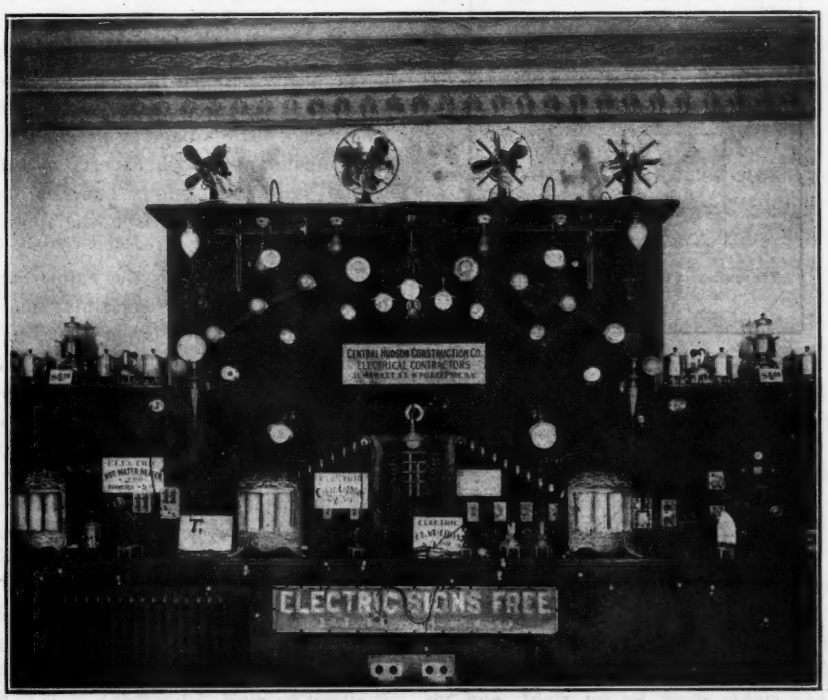


The display room of the Alliance Gas and Electric Company, at Alliance, Ohio, is a model for many much larger central stations, both as regards its get-at-ability and the up-to-snuffness of its general appearance.

It is not enough for the central station man to merely say, "Well, I will have a display room then, since you insist upon it."

Too many there have been who have gone into the display room proposition in just such a spirit, and the result is only too obvious to any one who happens along and sees this display room (save the mark!) that is nothing more nor less, and looks nothing more nor less, than a lot of electrical junk piled indiscriminately upon a table, or covered with dust and having all the outward appearance of being neglected from year's end to year's end.

Does any man think that such a display room is going to help any?



Poughkeepsie, N. Y., is one of the cities which can boast a live central station where the management believes in getting down close to the people and "demonstrating" what electricity will do.

On the other hand, we believe you can safely figure that such a display room will do a great deal more harm than good.

Far better not to bother with a display room at all than to go at it in such a half-hearted, lazy and careless spirit as that.

The display room should be kept right up to the minute, everything polished up, bright, clean, attractive looking and in order, so that, no matter when a demonstration is required, you will be dead sure that everything is "right."

It does much to cool a prospective customer's enthusiasm when he sees in the lighting company's own display room a number of things go wrong in the demonstration of the apparatus or device in which he is interested.

A sparking starting-box, an ill-conditioned fuse, a sign with one or more lamps burned out, all these are things which operate against the success of a new-business department, and are things which make an ill-conditioned display room far worse than none at all.

But if you are really in earnest in desiring to make your company successful in obtaining the greatest amount of business in your community, your display room will be one of your pet hobbies.

You will detail one of your best men to see to it that it is kept in good shape.

You will be constantly on the watch for new and attractive applications of electricity which you can occasionally introduce effectively and make your display department a constant source of attraction to the general public.

Your customers will drop in from time to time and will be continually tempted to look over the various exhibits to see if there is something new, and on seeing something which is a novelty may be depended upon to talk about it to the man in the street and the neighbor on the next door porch, and your company will gain much valuable publicity from your customers just along this line.

So long as the lighting company considered itself as nothing more than a distributor of electric current to those who came and insisted on having it there was no place in the central station almanac for such a thing as a display room, a show window, or any such important cogs of the new-business department.

But once central station men became infused with the idea that they were selling *not* electricity, *not* current, but light, heat and power, then arose the need for display rooms, efficient exhibits of various kinds, and every practical, sensible method of educating and converting the public to the adoption of electricity for these three great uses.

So long as it was merely a question of

selling current, the display room could not exist.

You can't show current.

The public could not see it and they would not care to feel very much of it.

But light, that's different.

The public has eyes, the man who wants light has eyes.

He is open to conviction through his eyesight.

If you can show him that one kind of electric light is better for one purpose, and that another kind is better for another purpose, and that all kinds of electric light are better for all purposes than gas light, or gasolene light, or kerosene light, or acetylene light, you are going to run a good chance of getting such a man on your books, where you would stand but little chance of getting him so long as you sat back in solitary splendor, and simply posed to him as a retailer of electric current.

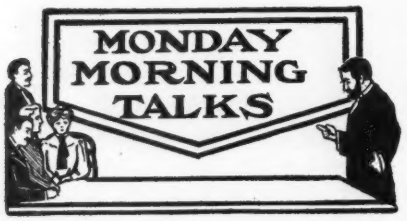
What does he know about electric current?

He knows in a vague way, perhaps, that electric current can be converted into light, and that's the end of it.

He knows in a still vaguer way that by some mysterious means electric current can be made to turn the wheels of machinery, but do you think he is going to be so foolish as to take a jump in the dark and install electric motors in his factory, so long as his knowledge of electricity is so ultra-kindergarten?

Not in a thousand years.

Nobody likes to adopt in his home or in his business something which he does not understand.



Under this general heading we shall present to our readers a series of bright, stimulating talks to solicitors, which, we believe, will prove valuable to managers of new-business departments in suggesting points which they can profitably bring out in their occasional meetings with the company's representatives.

We shall gratefully accept contributions and suggestions from any of our readers.

Some salesmen remind me of one of Josh Billing's sayings: "Trusting to luck is only another name for trusting to laziness."

They trust to luck when they call up a prospective customer or a customer by telephone instead of paying a personal visit.

They trust to luck when they pass by the little complaints their competitor will take advantage of.

By not thoroughly keeping in close, personal touch these same customers will gradually slip away until, lo and behold, the other fellow has them in a tight grasp.

To keep trade these days you must make your customer's business your business.

Show him the little hints and helps you learn from time to time.

Show him you are interested in his success, not in just getting his money.

Make him feel that all things being equal he'd prefer you to have the business. And when you get his confidence, keep it.

Feel that, personally, it is to your advantage to have him satisfied, and that any promise you make him will be fulfilled to the letter.

This kind of solicitor holds his trade, not only this year but in years to come.

Have you educated your trade to have that confidence in you?

Directions for Reading Electricity Meters.

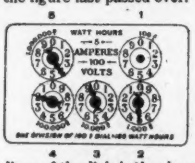
Electricity is measured by the kilowatt hour. 1 kilowatt equals 1000 watts.

1st. Note carefully the unit, as 10, 100, 1,000, etc., in which the dial reads. Counting from the right, the first dial which carries a pointer indicates 1 kilowatt for each division of the dial, and one division of each of the remaining dials indicates 10 kilowatts, 100 kilowatts, 1,000 kilowaats, etc., counting dials in regular order from right to left.

2nd. Note that successive dial pointers rotate in opposite directions.

3rd. Read the dials from right to left, setting down the figures as read. *Be sure* that you always read the figures on each dial which has been last passed or is just covered by the pointer.

Note carefully. Each dial reading depends on the reading of the one next to it on the right. Unless the one before it has completed a revolution, that is passed the 0, the pointer which is being read has not completed the division upon which it may appear to rest and still indicates the figure last passed over.



The readings of the dials in the above cut are:

Dial No.	5	4	3	2
Reads	4	1	9	5

Every salesman for this concern has an equal chance for business.

Every salesman has prospects that he hasn't yet succeeded in landing.

Every territory is a rich field with the chances of its becoming richer.

But it's distinctly up to you as to how much wealth you dig up.

Your energy and selling ability must be pointed in the right way—after trade that will yield with the right methods. Your sights must be set right, and no scattering shot used.

Because now you are after business for sure. Not merely wishing for it, but working for it.

Load your selling arguments with real reasons and have your talking points at your tongue's end.

Study your product until no argument invented will floor you—no reason so strong that you haven't a stronger one!

And, remember, have faith in your goods. Believe that electricity is *the* thing for light, for heat, for power. It is!

You have an equal chance to get as much business as ever came out of your territory if you show your prospect in the right light and the right way.

It will be our endeavor, from week to week, to present in this department brief notices of activities among the central stations, as gathered from men who are in the field and, consequently, in close touch with the progress of the new-business idea and its acceptance by central station managers. Contributions to this department are solicited, and will be received with much appreciation by the editor.

If you are doing something a little better than or different from the other fellows, and think it would make interesting reading to ELECTRICAL REVIEW readers, send in your schemes and plans. They will be gladly received.

Address all communications to Charles A. Parker, care of the ELECTRICAL REVIEW.

When one recalls the number of towns of good size ranging from five to ten and twelve thousand which are struggling along in this glorious year of grace without electricity between the hours of dawn and dark, it comes like a ray of sunshine to hear of a little village of five hundred or so inhabitants which expects to turn on the juice twenty-four hours a day within a very short time from the appearance of this article.

Elkhart Lake, Wis., is the happy burg under discussion, and certainly makes some of the very much larger places look sick by comparison, so far as new business activity and enterprise are concerned.

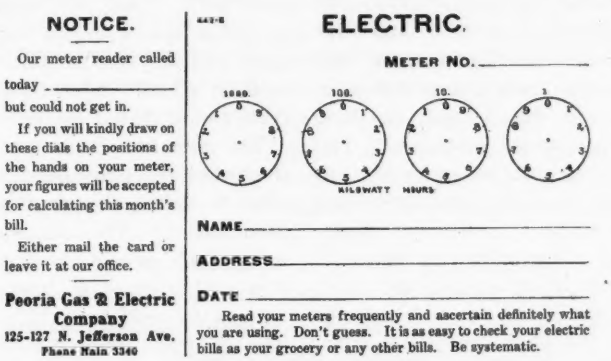
P. P. Brueckbauer is the manager of the Elkhart Lake Electric Company, and reports a healthy condition, all customers being on meter rate, and good prospects of a considerable demand for day-load current just as soon as the company gets around to giving the service.

Proofs of the company's aggressiveness are to be found in the fact that it has lately contracted for a forceful campaign of direct-by-mail advertising. It also makes it easy for the good people of Elkhart Lake to come into the electric fold by offering to wire residences on the instalment plan. In this way, the man who is hard-up and doesn't think he can af-

ford it has no excuse left for not having electricity in his home, especially when he is reminded by his good wife, who has read it in advertising matter, that the cleanliness of electricity saves decorating and cleaning bills, and the healthfulness of electricity will save doctor bills, so forth and so on.

J. M. Robb, of the Peoria Gas and Electric Company, Peoria, Ill., is so well known to the electrical fraternity as a successful new-business man that any suggestions from him, we feel sure, will be unusually interesting to other central station brethren.

One of the plans which has been carried out in Peoria very successfully is the sending out of meter reading cards, one of which we reproduce.


NOTICE.

Our meter reader called today _____ but could not get in.

If you will kindly draw on these dials the positions of the hands on your meter, your figures will be accepted for calculating this month's bill.

Either mail the card or leave it at our office.

Peoria Gas & Electric Company
125-127 N. Jefferson Ave.
Phone Main 3340

442-E

ELECTRIC.

METER NO. _____

1000. 100. 10. 1.

KILOWATT HOURS

NAME _____

ADDRESS _____

DATE _____

Read your meters frequently and ascertain definitely what you are using. Don't guess. It is as easy to check your electric bills as your grocery or any other bills. Be systematic.

You will notice that this card is used to send to houses where the meter reader was unable to get into the house, and the consumer is invited to fill in the meter reading and send same in to the company, with the understanding that his figures will be accepted as correct for calculating the month's bill.

Accompanying this card is another card (also shown) giving directions for reading electrical meters.

Mr. Robb reports that this little scheme has been a gratifying surprise, many of the cards having been returned filled in carefully, giving evidence that the consumers in question have given attention to the matter; and the Peoria company counts on these little cards assisting it to a very large extent in overcoming popular opinion that the company "fixes the bills" regardless of the meter readings.

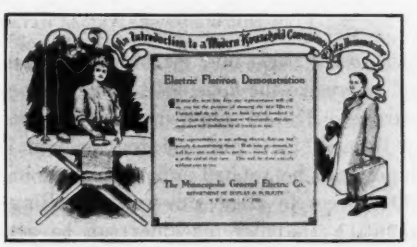
Another stunt of this company, which we believe must have a very excellent moral effect, is the returning to the consumer of the card shown, in which remittances are acknowledged in a very courteous manner, as will be noted from the reading matter shown on the card.

The Minneapolis General Electric Company has adopted a plan of sending out ahead of its solicitors special announcements in the form of mailing cards, and finds that this method, combined with the various other excellent advertising which the company is making use of, is productive of good results and especially makes the path of its solicitors easy by reason of the fact that they are expected and looked for by the people they call upon.

One of the cards which we reproduce reads as follows:

Within the next few days our representative will call upon you for the purpose of showing the new electric flat-iron and its use. As we have several hundred of these irons in satisfactory use in Minneapolis, this demonstration will doubtless be of interest to you. Our representative is not selling flat-irons, but merely demonstrating them. With your permission, he will leave one with you to use for one month, calling for it at the end of that time. This will be done entirely without cost to you.

We wonder sometimes if the city fathers of some of the small towns realize how greatly the question of progress and decadence of their town rests with the local electric lighting company and its policy. We believe if they did there would be less criticism and more appreciation for the progressive and enterprising local company.



For instance, in the little town of Delavan, Wis., it happens that there is a lighting company which is operated by modern business men, imbued with the spirit of the times to the extent that they make a special inducement to the merchants and business people of the town, offering current for window lighting and signs at extremely low rates from dusk until 10 P. M. Just think how the liberal use of electric light, as a consequence, separates that little town from many of its neighbors, where, if you landed after dark, you would find yourself wrapped in ——— shades.

Harold Almert has recently secured control of the Delavan Light and Power Company, and predicts that it will be but a short time before a large percentage of the village population will be using electricity.

This company has already awakened the desire for electric service in the breasts of many Delavanites by sending them, through the mail, a series of forceful and clever advertisements, and also has made considerable use of newspaper publicity.

A still further demonstration of the company's wide-awakeness is the fact that it has fitted up a nice office and display room, which latter is to be in charge of an expert illuminating engineer, who will devote all his time to getting new business and advising intending customers as to the wisest distribution of their light facilities and the most convenient provision for the various electrical devices which are coming so generally into use in homes, business places, etc.

H. Askin, superintendent of the Barnes Electric Light and Power Company, Maquoketa, Iowa, makes a suggestion regarding the soliciting of new business, which, he states, has met with considerable success in his territory. The idea is to solicit the various business houses and to install a string of lights in front of their places of business, with the understanding that a contract is to be signed up by each store so illuminated. The first fifty business houses were solicited, with the result that the remaining 150 or 200 in the town came and asked for an installation of electric lights. Mr. Askin believes that this idea could be followed up with much advantage in larger towns.

The Hicksville Electric Light Company, of Hicksville, Ohio, is in the throes of improvement. Building a new brick power-house, installing new equipment of increased capacity, etc., is keeping Manager C. M. Lott on the jump these days.

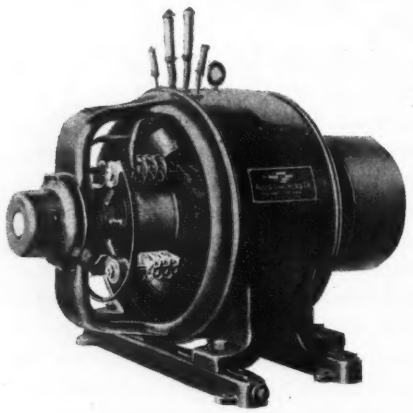
He is also casting covetous eyes in the direction of Antwerp, seven miles south, where the electric plant was burned in October last.

INDUSTRIAL SECTION

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS

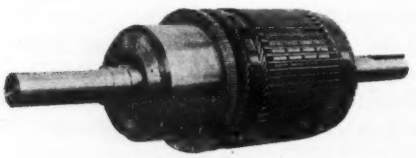
Allis-Chalmers Direct-Current Motors and Generators—Type "K."

The growing demand for direct-current electric motors that can be applied to the individual drive of machinery of various



ALLIS-CHALMERS TYPE "K" MOTOR.

kinds has led to a number of important changes in both the mechanical and electrical design of the motors heretofore used. To meet the requirements of this service the construction should not only be compact but also permit of mounting the motor in any position; while the windings and commutator must be either partially or wholly protected from external injury. Geared and direct-coupled methods of driving are rapidly displacing belts, and this, together with the fact that sudden and excessive overloads are of common occurrence, requires larger bearings and shafts of greater stiffness than were formerly used on motors of the same class.



ARMATURE OF SEVENTY-FIVE HORSE-POWER ALLIS-CHALMERS TYPE "K" MOTOR.

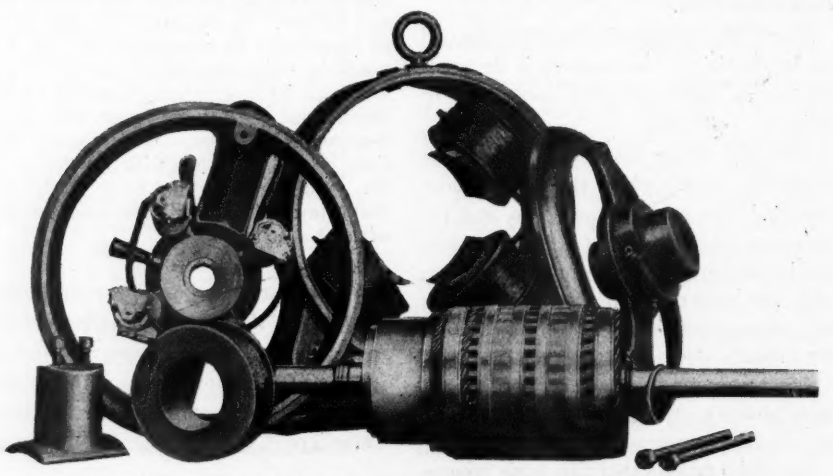
The demand for a wide variation in speed by shunt field control, with occasional heavy overloads at any speed, has also called for material improvement in commutating qualities.

The Allis-Chalmers Company, Milwaukee, Wis., announces a new line of direct-current motors, designed as type "K," which have been especially designed to meet these mechanical and electrical requirements. They are equally well adapted to belt drive at constant speed and continuous service, or geared drive, variable speed and intermittent service.

Their external appearance is similar to the well-known types "N" and "B" motors heretofore manufactured by that company, but the construction differs in many important details and, in fact, represents a new design throughout. The changes, both mechanical and electrical, are the result of many years' experience in the construction of motors for industrial purposes. The machine is very compact, the construction is rigid, and every detail has been worked out with especial reference to the most exacting requirements of modern service.

The cylindrical field magnet yoke is of open hearth steel and machined on each end to receive the housings that carry the bearings. The housings are held in place by through bolts and, on four-pole machines, can be rotated ninety degrees or 180 degrees to allow side-wall or ceiling mounting; bi-polar machines can be arranged for floor or ceiling mounting. The yoke is machined on the inside cylindrical surface and the poles are fastened to it by countersunk fillister-head cap screws. The pole cores are of open hearth steel and are circular in cross section; these cores are machined on one end to fit the inner surface of the cylindrical yoke and on the other to receive the pole shoes. The latter are built up of annealed steel punchings riveted together and fastened to the poles by flat-head machine screws. The pole face has been carefully shaped to give suitable distribution of the field flux, thus securing good commutation and preventing humming due to the armature teeth. The field cores are wound on metal spools, except for the smaller sizes, and are covered with sufficient insulation coated with varnish to protect them from external injury or moisture.

The armature cores are built up of sheet steel punchings insulated from each other to reduce the core loss and consequent heating. The laminations are keyed to the shaft, and in building up the core they are separated at intervals so as to form radial ventilating ducts. The punchings are firmly clamped between cast-iron end heads, which also serve as supports for the ends of the armature coils. In punching the armature laminations, openings are made in the discs, so that when the latter are assembled, ventilating passages are formed parallel to the shaft and connecting with the radial ducts. There is thus a free passage for circulation of air through the core, and all parts of the core and windings are thoroughly ventilated.



FIVE HORSE-POWER, ALLIS-CHALMERS TYPE "K" MOTOR, DISMANTLED.

The armature coils are form-wound and interchangeable; they are heavily insulated with stay binding and the whole armature is thoroughly impregnated with insulating varnish after it has been completely wound.

The commutator is of large diameter and ample wearing depth, having bars of

hard drawn copper insulated from each other and from the shell by the best quality of mica; the mica between bars is selected so as to give even wear. The clamping rings hold the bars very firmly, and the whole construction is such as to secure a perfect cylindrical surface free from high or low bars. The commutator sleeve, in all except the smaller sizes, is cored to permit the passage of air through to the armature.

The shaft is made of high-carbon steel which is very stiff and can stand heavy overloads without vibration or bending.

The bearings are amply large, and lubricated by oil rings which rest on the shaft and dip into oil wells beneath. The shaft projection for the pulley is turned smaller than the journals, so that the journal can be turned down, when worn, without reducing its diameter below that of the projection.

The brush-holders are of the reaction type, of the same general design as used on all Allis-Chalmers standard direct-current machines. They are simple in construction, positive in action, and allow the brush to follow the surface of the commutator freely. The brushes are held firmly to the holders and, while they can be readily removed for inspection, it is not possible for them to get out of place while in service. The brush studs are fastened to a rocker arm mounted on the bearing housing; this allows the brushes to be set at the best running position, but, after being once properly set they require no adjustment under any change in load within the range of the motor. The brushes are graphite and are connected to the holders by flexible copper shunts so that current is not compelled to pass through any sliding contacts; ample carrying capacity is provided in the brushes and brush-holders and all parts operate at low temperature.

The standard type "K" motor is made open at the ends to permit a free circulation of air through the machine; it can, however, be made semi-enclosed or totally enclosed by the addition of suitable metal enclosing covers which are readily fitted to the end housings. For the semi-enclosed type the covers are perforated, forming a screen cover which, while allowing a circulation of air, protects the motor from flying particles; this type of motor can be used on work where an open motor would not answer, but where an entirely enclosed one is unnecessary. Totally enclosed motors are dust and moisture proof, since the tightly fitting covers close up all openings. This shuts off the ventilation, and the output of a given frame for the totally enclosed type is less than for either the semi-enclosed or the open types.

These motors are manufactured in thirteen different frame sizes, and for each size there are a number of ratings, the output of a given frame being proportional to the speed.

Type "K" motors are suitable for all classes of work where either a constant or variable speed direct-current motor is required. For general driving of machinery or for variable speed work shunt wound machines are used. For cases where a large starting torque combined with the constant speed characteristic of the shunt motor is required, compound wound motors can be furnished. For crane and hoisting service series wound motors are supplied.

Type "K" machines operate exceptionally well as generators which are compound wound, and will deliver any current from zero to their full rated output without sparking and without shifting the brushes.

Type "K" machines are given the same high-grade finish that characterizes all Allis-Chalmers electrical apparatus. All castings are filled and rubbed down to a smooth surface. The workmanship is first-class throughout and all motors are thoroughly tested before being shipped.

Starting of Carnegie Steel Gas Engine.

Something over a month ago there was started at the Edgar Thompson works of the Carnegie Steel Company, Pittsburg, Pa., the first large gas power installation in America, using blast furnace gas and double-acting four-cycle gas engine of a large capacity. This event is of rather unusual importance as it marks the commencement of a new régime in methods of power generation of the United States Steel Corporation, which has already taken so prominent a stand in favor of the internal combustion type of prime mover. The starting of the Carnegie engine also is of further interest for the reason that it furnished an effective demonstration of the capabilities of the Westinghouse design for the work in hand. This design, however, was by no means an untried one, as a number of gas engine units of similar design, but smaller capacity (500 horse-power) have been in operation elsewhere with success; but the Carnegie engine represents the first of the series of twelve large units (3,000 horse-power) which are now being built by the Westinghouse Machine Company.

The Carnegie blowing unit was started for the first time on December 7, and after a trying out period of only two days, was then put into regular commercial service. Since then the unit has carried commercial load during the regular daily run without developing external or internal defects either in structure or operation. A rigid inspection of working parts after a few days' run failed to uncover the least evidences of wear or excessive stresses, and during a month's daily operation no prematures or backfires have occurred.

In design the gas engine follows the same general lines as those of smaller Westinghouse units, previously described in the technical press. It is of twin-tandem double-acting style with centre-hung flywheel and with two air tubs arranged in *vis-a-vis* fashion opposing the two engine frames. The gas cylinders are thirty-eight inches in diameter by fifty-four inches in stroke and air cylinders sixty inches in diameter; normal speed sixty to seventy-five revolutions per minute. Engines of the same size are being constructed for electric work, in which case the air tubs are removed and a generator mounted upon the shaft next to the flywheel. The generator will have a rated capacity of 1,500 kilowatts running at seventy-five revolutions per minute. Such a unit is now under construction for the Edgar Thompson plant. The generator will be solid coupled and will deliver direct current at 250 volts.

Although this gas engine unit furnishes an uninterrupted supply of air for blowing purposes, the duty imposed upon it is by no means uniform. Owing to changes in the compactness of the furnace burden the air pressure must vary in proportion. The usual range is fourteen to twenty pounds per square inch except when the furnaces are tapped, when the pressure reduces to five pounds. On the other hand, when the furnaces are closely packed the pressure may increase to twenty pounds. These variations in pressure delivery are accompanied by corresponding variations in the quantity of air delivered, all of which is taken care of by the valve gear, while the speed of the engine is entirely under the control of a sensitive centrifugal regulator designed upon the relay principle but controlling the gas inlets individually and directly at the point of gas supply. A speed chang-

ing mechanism provides means for manual control of the speed of the blowing unit when desired.

Compressed air is employed as usual for starting, and it is a point worthy of note that this large unit has been started and placed under full load in fifty-three seconds from the time of turning on the air, while one minute is ordinarily sufficient. As the starting is automatic, only gas and air valves require attention of the operator at the time of starting, no other parts of the engine needing manipulation.

Much experience has developed during the past two or three years in the operation of large gas engines on natural gas. It is, however, a point worthy of note that the use of "dirty" gas, either producer or blast furnace, is a very different problem, so difficult as to establish a very narrow margin between success and failure where the necessary experience in its use has not previously been acquired. But in adopting the large gas engine as a standard form of prime mover in steel plants, the Carnegie Steel Company has not been blindly dependent upon skill of gas engine designers. For a long period a 500-horse-power Westinghouse gas engine of design similar to the large unit was maintained in daily operation at the steel plant for purposes of experimentation. Experience derived from the operation of this smaller unit gave unusual promise, which seems to have already been fulfilled in the operation of the large unit. During a thirty-day test of twenty-four hours per day, including Sundays, this experimental unit sustained regular commercial load with but two stops (equivalent to a run of ninety-nine and one-third per cent of the elapsed time). One of these stops was due to failure of gas supply. At the end of this run the engine was found to be in excellent condition, no unusual wear had developed at any point and all moving parts were working freely. This excellent record is not a little due to the effectiveness of the lubrication and cooling systems which have been devised for this double-acting design of engine.

From every standpoint the results that have been achieved with the use of blast furnace gas at the Edgar Thompson works constitute nothing less than a vindication not only of the design, but also of the action of the steel companies in adopting gas engines for general motive power throughout every department of their works.

Electrical Advertising for Central Stations.

The accompanying illustration shows a new form of advertising novelty recently placed on the market by the Solar Electric Company, 161 South Canal street, Chicago, Ill. This is made in the shape

ADVERTISING GLOBE FOR INCANDESCENT LAMPS.

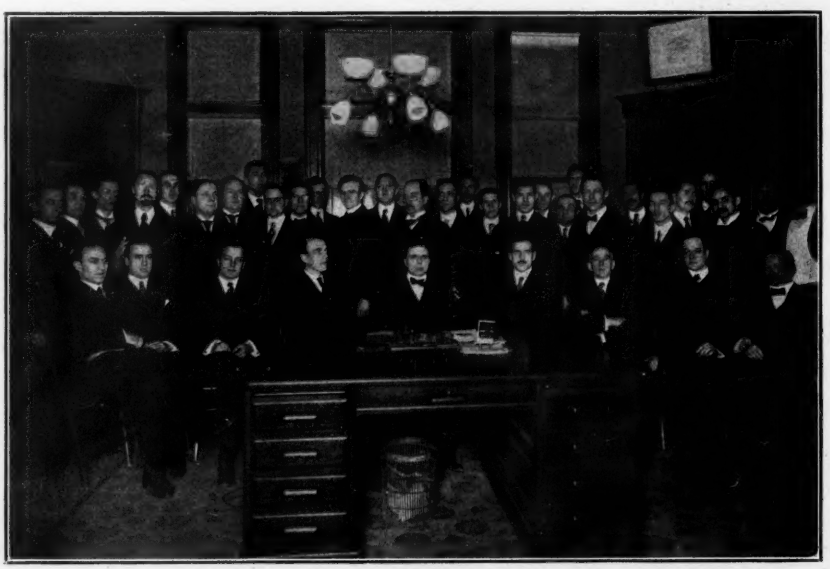
of a ground-glass globe properly lettered and equipped with a sixteen-candle-power lamp and flasher. This flashes the light on and off continually and makes an attractive advertising device. The Chicago Edison Company, Chicago, Ill., and the Union Electric Light and Power Company, St. Louis, Mo., are making a liberal use of this device.

Crocker-Wheeler Annual Convention.

The accompanying photograph was taken at the annual convention of the Crocker-Wheeler Company, at the main office and works, Ampere, N. J., in January. As usual it shows that few changes have been made in the personnel of the company since the convention of January, 1906. One of the facts brought out at the convention was that the company did more business in 1906 than any other year since it was started more than eighteen years ago.

President Schuyler Skaats Wheeler informed the selling men, who had come together from all over the country, that the company was in better shape than ever to extend its facilities and to develop the lines in which it has already achieved extraordinary success, notably during the past year. Three important specialties of the company are alternating-current generators and transformers of large capacity, direct-current motors of small capacity and motors of every size for machine-tool drive.

The success that has come to the Form W rolling mill motor is perhaps the most unusual achievement since the last convention when this motor was first announced and described by Gano S. Dunn, chief engineer and first vice-president of the company.



CONVENTION OF BRANCH OFFICE MANAGERS AND OFFICERS OF THE CROCKER-WHEELER COMPANY, AMPERE, N. J.

On Friday evening, January 25, the convention gathered at dinner at the University Club.

Those shown in the photograph are as follows:

Beginning at the left hand, upper row, J. R. Wilson, W. C. Appleton, H. B. Hussey, R. N. C. Barnes, C. W. Startsman, A. P. Olds, J. B. Milliken, H. C. Petty, G. H. Hall, H. Fuller, H. J. Sage, W. S. Watson, F. W. Kreps, S. Russell, Jr.; H. M. Gassman, H. Lomas, J. M. Smith, M. E. Weissblatt, D. N. Force, Jr., Julian Roe, R. B. Treat, L. S. Horner, H. Pikler,

C. N. Wheeler, H. A. Knoener, F. Young, A. Hartman, B. A. Schroder, (front row beginning at left) Rodman Gilder, R. J. Randolph, Jr.; H. L. Patteson, A. L. Doremus (second vice-president), S. S. Wheeler (president), Gano S. Dunn (first vice-president), W. L. Brownell (treasurer), F. B. DeGress and G. W. Bower.

THE MEETING OF THE BUCKEYE CLUB AT THE WORKS OF THE HEMINGRAY GLASS COMPANY, MUNCIE, IND.

The Meeting of the Buckeye Club.

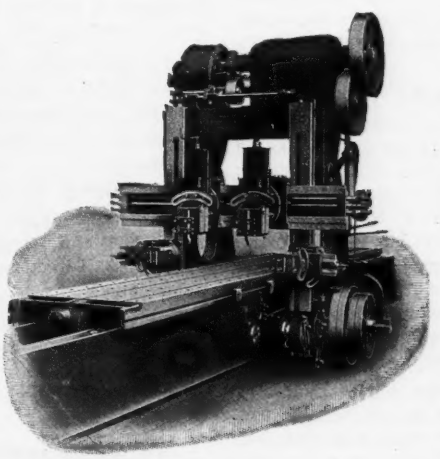
The accompanying illustration is a reproduction of a photograph taken during the recent meeting of the Buckeye Club assembled at the works of the Hemingray Glass Company, Muncie, Ind. The Buckeye Club consists of jobbers in electrical supplies from the states of Pennsylvania, Ohio, Michigan, Indiana and Kentucky.

"American" Variable-Speed Planers.

The American Tool Works Company, Cincinnati, Ohio, has placed on the market a new line of variable-speed planers, one of which is shown in the accompanying illustration. These planers are built in two types, one with four cutting speeds, and the other with two cutting speeds, each type having a constant-speed return of the platen. This return speed is greatly in excess of its respective highest cutting speed.

These planers are adapted for either belt or motor driving, and the speeds are obtained by means of a speed box, in the design of which the aim has been to secure efficiency, simplicity and durability. The speeds are taken from a carefully chosen range calculated to cover all requirements of modern planer work. This, with the high-speed return of the platen, ensures high working economy.

The speed box is securely bolted to the top of the housings, these being of special design and substantially made. The box is symmetrical in appearance and is completely enclosed, ensuring economy in oil consumption and freedom from spraying of oil.



"AMERICAN" VARIABLE-SPEED PLANERS.

The shafts in the speed box run in long bronze bushed bearings lubricated by a ring system of oiling. The gears run in oil, giving a long life and noiseless operation. The gears are of ample proportions, with wide faces and coarse pitch. The pinions are of solid steel, cut integral with their shafts.

Any of the four speeds may be obtained by the simple manipulation of two convenient levers.

A safety locking device prevents the engaging of two conflicting speeds at one time. The index plate shows clearly how to obtain the desired speed.

The driving pulleys have flywheel rims, the momentum of which reduces to a minimum all shocks to the driving mechanism due to intermittent cutting, and at reversing ensures a steady, even pull at the cutting tool.

With the two-speed type the speeds are obtained by means of a simple and efficient two-speed countershaft, which is attached to the ceiling in the usual manner. This countershaft is equipped with a self-oiling feature, ensuring minimum attention and long life.

Sunbeam Tungsten Lamps.

Experiments are now being conducted by the engineering department of the Sunbeam Incandescent Lamp Company, on tungsten metallic filaments, and as a result of recent developments the Western Electric Company reports that it will, no doubt, be among the first of the companies which will be in position to furnish these lamps to the trade. This is an eighty-candle-power lamp, with a total wattage of 100, or one and one-fourth watts per candle-power. The lamp is not yet offered for sale.

Current Electrical News

DOMESTIC AND EXPORT.

CHICAGO TELEPHONE PETITION—The Chicago Telephone Company has filed with the Chicago (Ill.) city clerk a petition with 100,000 signatures requesting that a telephone franchise be granted the Chicago Telephone Company. President A. D. Wheeler of the company sent a letter to Mayor Dunne asking that the petition be considered by the council in the pending negotiations for a renewal of the franchise.

BROOKLYN RAPID TRANSIT COMPANY TO INCREASE POWER OUTPUT—Announcement that the size and capacity of its new Williamburg power plant, at Kent and Division avenues, Brooklyn, N. Y., are to be doubled has been made by the Brooklyn Rapid Transit Company. This will give the company a plant capable of generating 150,000 horse-power, or 30,000 horse-power more than is required to operate the entire Brooklyn Rapid Transit system in its heaviest rush hour. The structure will be ten stories high and will cost $5,500,000.

POWER COMPANY FOR CITIES OF NEW YORK STATE—The Economic Power and Construction Company, of Albany, has filed a mortgage in the county clerk's office to the New York Security Company for $250,000 on its franchise and property. It is stated that the company intends to construct and operate plants in Buffalo, Rochester, Syracuse, Utica, Schenectady, Troy, Albany, Yonkers and New York city. It is believed that the company will take its power for distribution from Niagara Falls. The charter was obtained some years ago. The president is William K. McFarland, and the secretary Bert M. Jones.

PENNSYLVANIA TROLLEY SYSTEM PURCHASED—The Lancaster (Pa.) County Railway and Light Company, which embraces all the trolley lines in the city and county, except the York Furnace and Rawlinsville lines, and the electric light and gas companies in Lancaster city and Columbia, has been sold to the McCall's Ferry Power Company for $3,000,000, with the obligation that the purchasing company shall add to the treasury of the local corporation $1,000,000 for needed improvements. There will be no material change in the management of the trolley system, with the exception that there will be one or more representatives of the McCall's Ferry Company on the board of directors.

MILWAUKEE ELECTRIC STATEMENT—The report filed by the Milwaukee Electric Railway and Light Company with the comptroller at Milwaukee shows that there is $4,500,000 outstanding preferred stock and $9,000,000 common stock. The bonded indebtedness is $11,000,000, outside of interest, $1,332,210; railroad receipts, $2,973,443; disbursements, outside of interest, $1,931,514; cost of transportation, $945,238, and reserve funds, $352,343. The corporation paid for injuries and damages for the year $118,937. Its legal expenses were $29,734 for the year. The dividends were $81,000. The Milwaukee Light, Heat and Traction Company, which operated interurban lines, paid no dividends. Its legal expenses for the year were $6,005 and it paid for injuries $24,223.

TO LAY CABLE TO CUBA—The application of the Central & South American Telegraph Company to land an ocean cable connecting the United States with Cuba and the Canal Zone was discussed at a meeting between Attorney-General Bonaparte, Secretary Taft, General Allen, chief signal officer of the army, and representatives of the telegraph company. The company proposes to lay a cable from Sandy Hook to Guantanamo, Cuba, and thence to Colon or Cristobal, connecting by land lines across the Isthmus with the Pacific cables. The government will agree, as a result of the conference, to the laying of the cable as proposed, but it will effect an agreement with the company by which the United States will have control of the line in time of war. This will be done by exercising control over the landing places of the cables.

INDIANA TROLLEY MERGER—Under the title "Chicago, South Bend & Northern Indiana Railway Company," the properties consisting of the traction lines between Goshen and South Bend and between Laporte and Michigan City, as well as the street railway systems of South Bend, Goshen, Elkhart, Mishawaka, Laporte and Michigan City, have been incorporated in Indiana. The roads were recently purchased by the Dieterich-Murdock syndicate from Arthur Kennedy, of New York, and his Pittsburg associates, for $4,000,000. The new company is incorporated for $7,500,000. It is intended to build at once a line from South Bend to Chicago by way of Michigan City. The officers of the new company are: president, Charles T. Dieterich, New York; vice-president, Charles L. Murdock, Lafayette, Ind.; treasurer, Alfred Dieterich, New York, and general manager, Samuel T. Murdock, Lafayette, Ind.

NEW INCORPORATIONS.

PITTSBURG, PA.—Friendship Avenue Street Railway Company; $27,000. Linden Avenue Street Railway Company; $15,000.

CHICAGO, ILL.—Chicago City Railroad Company. $100,000. Incorporators: R. B. Hamilton, John R. Davies and R. N. Seney.

RALEIGH, N. C.—The Union Power and Water Company, Raleigh. $100,000. Incorporators: S. B. Shepherd, W. W. Vass.

AUSTIN, TEX.—The Corsicana Telephone Company, of Corsicana. An amendment to its charter increasing its capital stock from $100,000 to $200,000.

DENVER, COLO.—Crested Butte Telephone Company. $10,000. Incorporators: J. W. Rockefeller, S. C. Robinson, Angus Taylor, V. E. Metzer, Ira L. Sigman, C. J. Diehl, Philip Hamlin, Crested Butte.

GUTHRIE, OKLA.—The Dane & Fairview Telephone Company, of Fairview. $1,500. Incorporators: A. A. Crump and W. S. Whittinger, of Dane; Brice Lowell, H. Clay Willies and V. G. Jones, of Fairview.

AUSTIN, TEX.—Dublin Farmers' Rural Telephone Company, of Dublin. $20,000. Incorporators: J. G. O'Brien, R. L. O'Brien, M. D. Gallagher, J. M. Higginbotham, Q. H. Humble, all of Dublin; J. H. Tull, of Crelton, Tex.

BLOOMINGTON, ILL.—Corn Belt Traction Company. Organized to build an interurban line from Champaign to Bloomington. $100,000. Incorporators: William McKinley, Peter Moore, Earl Riddle, of LeRoy, and L. B. Thomas and Henry C. Lasch, of Bloomington.

ALBANY, N. Y.—Canandaigua Southern Electric Railroad Company, of Canandaigua, Ontario county. To operate an electric road thirty-three and one-third miles long, from Canandaigua to Atlanta. $1,000,000. Directors: E. G. Hayes, A. Davidson, G. Packard, Canandaigua.

MADISON, WIS.—Waupaca-Green Bay Railroad Company. To build and maintain a road from Waupaca, northeast to Scandinavia, a distance of eleven miles. $150,000. Incorporators and stockholders: A. G. Nelson, A. M. Renney, John Gordon, A. Aggerbeck and W. B. Johnson.

COLORADO SPRINGS, COLO.—Garden City Telephone, Light and Manufacturing Company. $150,000. To furnish telephone and electric light service to Garden City. Directors: E. L. Wirt, E. E. Wade, both of Garden City, and F. R. Marsh, C. V. Turner, C. W. Kurie and W. H. Spurgeon, all of Colorado Springs.

ALBANY, N. Y.—The Seashore Municipal Railroad. To build and maintain a street surface electrical railroad five miles in length, extending from the village of Hempstead to East Rockaway, Nassau county. $150,000. Directors: P. K. Ames, of Long Beach; H. D. Bristol, of Rockville Centre; M. H. Day, of Brooklyn; H. W. Griffiths, of Hempstead; R. M. Lamb, and Henry Olmstead, Jr., of Freeport, and A. M. Peatt and A. M. White, of New York city.

ELECTRIC RAILWAYS.

DES MOINES, IOWA—Farmers in Ivy township, east of this city, have organized a company to build an interurban line to Prairie City. They have agreed to secure right of way and assist any interurban company that will help them get electric railway connections.

COLUMBIA, S. C.—The Columbia Electric Street Railway has elected the following officers: Edwin W. Robertson, president and treasurer; Lewis W. Parker, first vice-president, and William Elliott, Jr., second vice-president and general manager. The company is in a most prosperous condition.

COLUMBUS, OHIO—The Toledo & Western Railroad Company has filed with the secretary of state a certificate of the increase in its capital stock from $10,000 to $2,000,000. The company was recently incorporated by G. C. Ford and others to build an electric line from Toledo to the Indiana state line.

COLUMBIA, PA.—Rights of way have been secured for an electric road that will run from Millersville to Columbia by way of Creswell and Washington borough. At Millersville connection will be made with the electric road running to Lancaster, thus giving Columbia communication by two routes with the county seat.

ALLIANCE, OHIO—The stockholders of the Stark Electric Railroad Company, whose line runs from Canton to Salem, *via* Alliance, have elected officers as follows: president, C. R. Morley; vice-president, D. Morrison; secretary, E. S. Cook; treasurer, E. Wiebenson. In addition to the above the directors are William Grief, R. H. Brown and Frank Straus. All the officers are from Cleveland.

IRWIN, PA.—The borough council has granted a franchise to the Pittsburg & Westmoreland Railway Company. This line is projected to run from McKeesport to Irwin and from there south to Herminie, under a state charter. The local franchise is for a term of thirty years. It also provides for a commutation ticket at a cent a mile for long hauls and a cash payment of $5 a foot for streets occupied.

CONNELLSVILLE, PA.—George W. Campbell has inaugurated a movement for the building of an electric line from Connellsville to Normalville and on to Ohiopyle. It is also planned to have it go through the new Hogg addition to Connellsville and touch the Berryhill Klondyke, formerly known as McCoy's Springs, where a park will be located. James B. Hogg, a local capitalist and property owner, is also interested.

TOLEDO, OHIO—At the annual meeting of the Toledo Railways and Light Company the following officers and directors were reelected for the coming year: directors, L. A. Beilstein, Henry A. Everett, Albion E. Lang, Edward W. Moore, William L. McKenna, Robert B. Van Cortland and Charles W. Mason; chairman of the board, A. E. Lang; president, Henry A. Everett; vice-president, L. A. Beilstein; secretary, Herman S. Swift; treasurer, Spencer D. Carr.

ITHACA, N. Y.—The Ithaca-Seneca Falls Interurban Electric Trolley Company has elected the following officers: president, Jacob Rothschild, Ithaca; vice-president, Cornelius S. Hood, Seneca Falls; secretary, J. N. Hammond, Seneca Falls; treasurer, Francis M. Bush, Ithaca. These officers, with the following, will constitute the board of directors: Thomas J. Clary and Olin E. Emmons, of Seneca Falls; Fred L. Hawes, of Ithaca; William P. Riggs, of Trumansburg; Ogden Wheeler, of Romulus.

OMAHA, NEB.—At the annual meeting of the Omaha & Council Bluffs Street Railway Company all old officers and directors were reelected. The directors are: Guy C. Barton, G. W. Wattles, W. V. Morse, W. A. Smith, of Omaha; C. B. Tyler, of Council Bluffs; Randall Morgan, of Philadelphia; Albert Straus, of New York; Hugh McGowan, of Indianapolis. Officers chosen for the year are: Guy C. Barton, president; G. W. Wattles, vice-president; W. A. Smith, general manager and treasurer; R. A. Leussler, secretary and assistant general manager.

WORCESTER, MASS.—At the annual meeting of the Worcester Railways and Investment Company, Charles S. Mellen, president of the New York, New Haven & Hartford Railroad Company, was elected a member of the board of trustees and will represent the New Haven company on the board. He succeeds Samuel Carr, of Boston. Francis H. Dewey, president of the Worcester Consolidated Street Railway Company, was reelected to the board of trustees. The income account of the Worcester Railways and Investment Company, for the year ended December 31 last, shows gross earnings of $283,318, an increase of $46,036 over 1905. Net earnings after the payment of dividends were $14,177. During the year the Marlboro & Westboro street railway was purchased and on December 18 the new line to Leominster was opened.

ALBANY, N. Y.—The merger of the Bennington & Hoosick Valley Railway with the Bennington & North Adams Street Railroad has been consummated by the filing of the necessary legal papers with the secretary of state. The merger really means, it is said, the absorption of the two companies by the New York, New Haven & Hartford Railroad. The capital is given as $650,000. The roads consolidated form a part of an interstate trolley-car system, which the New Haven interests now have in New York, Massachusetts, Connecticut and Vermont. By the merger, President Mellen, of the Consolidated Railway Company, has secured additional franchises for rights of way into Troy and Albany. The new board of directors is: C. S. Mellen, Calvert Townley, A. S. May, J. G. Parker and H. M. Kochersperger, of New Haven; George E. Greene, of Hoosick Falls; F. E. Gibson, of Bennington; A. B. Gardiner, of Pownal, Vt., and H. W. Ely, Westfield, Mass.

UTICA, N. Y.—The Mohawk Valley Company, the holding corporation for the electric companies in which the New York Central Railroad is interested, held its annual meeting recently. The following directors were elected: Horace E. Andrews, John Carstensen, William J. Wilgus, Walter N. Kernan, Edward V. W. Rossiter, William C. Brown and W. K. Vanderbilt, Jr. The inspectors of election were William H. Dunkerley, R. E. McDougall and Milford Badgers. The Rochester Railway and Light Company, which controls the local and suburban electric lines in Rochester, has held its annual stockholders' meeting. Horace E. Andrews, of Cleveland, is the president of the company, and A. L. Linn, Jr., formerly of Utica, is the assistant secretary and the general auditor. John J. Stanley, formerly general manager of the local street railway, is a director and a member of the executive committee of four. Walter N. Kernan, of Utica, has been made a director of the Rochester Railway Company. Mr. Linn is the assistant secretary and the general auditor of the Rochester Railway Company, the Rochester & Sodus Bay Company, the Rochester & Suburban and the Rochester & Eastern Rapid Transit Company. Mr. Andrews is the president of the four corporations, which are also under the control of the Utica & Mohawk Valley Railway Company.

NEW PUBLICATIONS.

UNITED STATES NAVY DEPARTMENT—The chief of the bureau of steam engineering, United States Navy Department, has issued his annual report for 1906.

WORCESTER POLYTECHNIC INSTITUTE—The Worcester Polytechnic Institute, Worcester, Mass., has issued its thirty-seventh annual catalogue, dated January, 1907. This includes descriptions of the courses offered and of the college buildings, a register of students enrolled and a list of graduates.

THREE-YEAR TOPICAL INDEX OF THE *ELECTRIC JOURNAL*—The Electric Club, Pittsburg, Pa., has published a three-year topical index of the *Electric Journal*, with an index to authors. This topical index for the first three volumes of this journal makes it unnecessary to look up the individual volume indexes in seeking reference to the various articles.

THE ELECTRIC RAILWAY AND THE MUNICIPALITY—There has been reprinted in pamphlet form the address delivered by the Hon. Henry J. Booth, of Columbus, Ohio, at the twenty-fifth annual banquet of the American Street and Interurban Railway Association, Columbus, Ohio, October 18, 1906, entitled, "The Electric Railway and the Municipality."

MAINTENANCE OF PAVEMENTS AND ADMINISTRATION OF STREETS IN THE CITY OF NEW YORK—The Merchants' Association of New York has issued a pamphlet entitled, "Maintenance of Pavements and Administration of Streets in the City of New York," this comprising a report to the Merchants' Association by its committee on city conditions.

ELECTRIC LIGHTING.

HENNESSEY, OKLA.—Work has commenced on the electric light plant and it is hoped to have it completed in four months.

BRUNSWICK, ME.—Complete control of the Brunswick Electric Light and Power Company has been secured by the Hon. Charles Sumner Cook, of Portland.

WASHINGTON, PA.—The borough council has contracted with the Washington Electric Light Company to furnish light for the borough streets for five years.

PHILIPSBURG, N. J.—The council has awarded the electric lighting contract to the Easton Gas and Electric Light Company for a period of five years, at $65 per arc light.

ALVIN, TEX.—A stock company with a capital of $15,000 has been formed to install an electric light plant in Alvin, and also to manufacture ice and do a refrigerating business.

TEAGUE, TEX.—G. F. Guggolz, of Mart, Tex., has entered into an agreement with the Ten Thousand Club to install an electric light plant in Teague, work to begin within thirty days.

BOSTON, MASS.—The Cambridge Electric Light Company has petitioned the gas commissioners for authority to issue $100,000 additional capital stock to take up the floating debt incurred for improvements.

GLENS FALLS, N. Y.—At the annual meeting of the Hudson River Power Transmission Company the following officers were elected: president, Eugene L. Ashley; vice-president, W. H. Trumbull, of Boston; secretary and treasurer, Elmer J. West.

SPRINGFIELD, OHIO—A merger of the two electric lighting companies of Springfield, the Home Lighting, Power and Heating Company, owned by E. S. Kelly, and the People's Light, Heat and Power Company, a stock company, is said to be nearing consummation.

LA CROSSE, WIS.—In order to accommodate its rapidly increasing business, the La Crosse Gas and Electric Company is practically doubling the capacity of its plant. An addition 70 by 150 feet long, is being erected and an extensive supply of new machinery is being installed.

STILLSVILLE, N. Y.—The president of the village of Stillsville, Oneida county, N. Y., has called a special election of its taxpayers to vote on the proposition of lighting the streets electrically. The plan seems to be favored. It is proposed to use at least 150 arc lights.

CHEYENNE, WYO.—W. J. Barker, of Denver, president of the Northern Colorado Power Company, states that the company will, in thirty days, begin the construction of a new electric plant in Cheyenne and have it in operation by June 15. One million dollars will be expended on the plant.

CAMBRIDGE, NEB.—The third annual meeting of the stockholders of the Cambridge Electric Light Company was held January 15 at the office of the treasurer. The following were elected as the board of directors for the ensuing year: W. H. Falling, George Williams, J. H. Rosenfelt, E. C. Rodwell.

HUNTSVILLE, ALA.—The light committee of the city council has been instructed to look into conditions and ascertain if it is advisable for the city to issue bonds and establish a municipal lighting plant. The city has the power to do this at any time. The committee has taken up the question because of the unsatisfactory service now given.

MILWAUKEE, WIS.—Resident Engineer H. S. Brown has informed the finance committee that a municipal light plant furnishing power for 3,000 arc lamps and 10,000 incandescents would cost $1,000,000. In the beginning the plant would supply only about 2,200 arc lamps with provisions for extension, so the initial cost would not be that high.

TRENTON, N. J.—The Trenton Water Power Company has been sold to Victor Humbrecht, of Philadelphia. Mr. Humbrecht has been making some extensive purchases in this vicinity lately, among them being the Hough and other farms near Yardley, and a large tract of land near Hutchinson Mills, Hamilton township, for the Trenton Manufacturing Site Company.

COLUMBUS, OHIO—George W. Bright, William A. Gill, Emil Kiesewetter, John Siebert and Adolph Theobald have been elected directors of the Columbus Edison Company. The board elected officers as follows: Adolph Theobald, president; John Siebert, vice-president; Emil Kiesewetter, secretary and treasurer; L. F. Kiesewetter, assistant secretary and transfer agent.

BRADFORD, PA.—At the annual meeting of the Bradford Electric Light and Power Company the directors elected were as follows: T. F. Connelly, John Potts, John Scott, J. H. Rose, D. W. Robertson. Officers were elected as follows: president, George H. Potter; vice-president, D. W. Robertson; treasurer, Frank Hamilton; secretary and general manager, J. H. Rose.

SOUTH HADLEY FALLS, MASS.—The officials of the South Hadley Falls Electric Light Company expect to have a modern lighting plant in the near future. A 650-horse-power Fitchburg steam engine is to be installed and also a 2,000-light generator. The company has been handicapped in the past by the fact that its facilities were not of sufficient power to meet the requirements.

AMERICUS, GA.—The city council of Americus has awarded to W. A. Dodson and associates the franchise for electric utilities. The contractors will immediately install a power plant and construct an electric street railway of four miles circuit. The company proposes taking over the old electric and gas plant, but will install entirely new and modern machinery at once.

EATON, OHIO—The Eaton Electric Light, Ice and Power Manufacturing Company, at its annual stockholders' meeting, elected a board of directors as follows: R. K. DeMotte, W. C. Dove, Robert Hiestand, Solomon Lander, George H. Kelly, Jonas Markey. The board organized by selecting officers as follows: president, Jonas Markey; vice-president, George H. Kelly; secretary, W. C. Dove; treasurer, R. K. DeMotte.

NASHVILLE, TENN.—In the issue of the ELECTRICAL REVIEW for January 19 announcement was made that work would be begun on the electric power plant to be erected at Caney Fork Falls, and that C. H. Fisk and C. W. Post, of Michigan, would control the power plant. We are advised that C. W. Post, chairman of the Postum Cereal Company, Limited, Battle Creek, Mich., is in no way connected with this project.

NIAGARA FALLS, N. Y.—The common council has adopted a resolution providing that the cost of building and maintaining a municipal electric light plant be investigated, the cost at which electricity can be sold to citizens and generated for municipal purposes be determined, and that in the event that it be found that the city can provide cheaper light and power than it is now receiving from the Buffalo & Niagara Falls Electric Light and Power Company, the city take steps to build and equip a municipal plant. All the aldermen voted in favor of the resolution.

CAMBRIDGE, MD.—The Dorchester Public Service Corporation, incorporated recently in Baltimore, has received a franchise for the installation of an electric light plant in Cambridge from the board of town commissioners. The company agrees to erect a plant to cost not less than $70,000 and to have it in operation by May 1, 1908. The plant is to be capable of furnishing power for all purposes in Cambridge and also have sufficient capacity to run an electric railroad from Cambridge to Fox Creek. At the end of ten years the city of Cambridge is to have the right to purchase the plant and business at a price to be fixed by five appraisers.

NEW HAVEN, CT.—It is reported that the Consolidated Railway Company has sold its New Britain lighting plant to the Hartford Electric Light Company. The Hartford company sells light to the city of Hartford at $70 a lamp, which is about $15 a lamp cheaper than New Britain is paying, and that the Hartford price will be put in operation at New Britain under the new management is believed. The negotiations provide for the sale of the plant on Chestnut street, which was abandoned by the Connecticut Railway and Lighting Company when it arranged for securing power from Bulls Bridge. Under the new régime it is stated that the Chestnut street plant will again be pressed into service.

PERSONAL MENTION.

MR. THOMAS H. BIBBER has resigned from the American Circular Loom Company, Chelsea, Mass.

MR. GEORGE H. DODGE, formerly superintendent of the West Chester, Kennett & Wilmington Electric Railway Company, has been chosen secretary and treasurer of the Coatesville & Kennett Railway Company, which is building a sixteen-mile road between Coatesville and Kennett Square, Pa.

MR. E. H. HAUGHTON, manager of the Bryan-Marsh Company, Chicago, Ill., is the happy recipient of many congratulations upon the birth of a baby daughter several weeks ago. The announcement of this event was one of the important features of the first week of the Chicago Electrical Show.

MR. HENRY DOCKER JACKSON announces the removal of his office from 4 State street, to room 626 Broad Exchange Building, 88 Broad street, Boston, Mass., where he will carry on his business of consulting electrical engineer. He will make a specialty of reports on electrolysis, power distribution for mills, railways and lighting companies, power-plant economy and on proposed or existing plants for financial houses.

MR. F. N. BUSHNELL has tendered his resignation as chief engineer of the Rhode Island Company and the Narragansett Electric Lighting Company, and will be identified with the Stone & Webster Engineering Corporation, of Boston. Mr. Bushnell has been a conspicuous figure in Rhode Island engineering for several years. He was born in Saybrook, Ct., and went to Providence, R. I., in 1883 to learn the machinist's trade, entering the shops of the Providence Steam Engine Company as an apprentice. He later became designing engineer of this company, and then went to Chester, Pa., with Robert Wetherell & Company, builder of Corliss engines. He returned to the Providence Steam Engine Company as superintendent, going in 1893 with the Fuller Iron Works. Later in the same year he was appointed chief engineer of the Narragansett Electric Lighting Company. When Marsden J. Perry took charge of the Providence street railway system, Mr. Bushnell was appointed chief mechanical engineer of the traction company. In 1903 he also became chief engineer of the Rhode Island Company.

OBITUARY NOTES.

MR. DAVID LOGAN, an electrical engineer, who for several years was connected with some of the city departments in Manhattan, died on January 27, at his home, 959 Madison street, Brooklyn. He was born in England fifty-seven years ago and had lived in Brooklyn for thirty years. He leaves a widow, three sons and a daughter.

MR. JOSEPH T. MURRAY, New York city, the first partner of Thomas A. Edison, died in Springfield, Mass., on January 27, at the home of his daughter. Mr. Murray was seventy-two years old. In the early seventies he met Mr. Edison and formed a partnership with him in Newark, N. J., under the name of Edison & Murray, to manufacture telegraph instruments.

MR. HENRY G. SERGEANT, until recently president of the Ingersoll-Rand Company, died at Westfield, N. J., on January 31. Mr. Sergeant contributed largely to the development of the pneumatic drill, and is identified with street railway interests as the inventor of the ticket-canceling boxes established on most of the elevated railway stations throughout the country.

ELECTRICAL SECURITIES.

While every full day last week witnessed a stock transaction business in New York city in excess of a million shares, the effect was in the main a continuance of selling and a further decline in prices all along the line. The result has been, of course, unsatisfactory to many concerned, but as a weak point has been thus eliminated, the stability of the market has been enhanced, and a condition brought about where there is a possibility of healthy growth, instead of that which prevailed for so long a time last year—inflated values and false conceptions of opportunities having been the rule. That there is little apprehension felt by the larger interests is shown in the cheerfulness and faith with which new securities are being offered, the issue of $40,000,000 in bonds by the American Telephone and Telegraph Company, being a noteworthy feature last week. The reports from industrial centres indicate, also, that the present prosperity of the manufacturers is being well maintained, with the outlook bright for a busy and profitable spring and summer campaign.

ELECTRICAL SECURITIES FOR THE WEEK ENDING FEBRUARY 2.

New York:	*Closing.*
Allis-Chalmers common	14½
Allis-Chalmers preferred	37⅛
Brooklyn Rapid Transit	72
Consolidated Gas	133½
General Electric	158
Interborough-Metropolitan common	35
Interborough-Metropolitan preferred	72
Kings County Electric	140
Mackay Companies (Postal Telegraph and Cables) common	71¼
Mackay Companies (Postal Telegraph and Cables) preferred	69½
Manhattan Elevated	142⅞
Metropolitan Street Railway	104⅛
New York & New Jersey Telephone	112
Western Union	82½
Westinghouse Manufacturing Company	150

The earnings of the General Electric Company for the fiscal year ending January 31, 1907, it is stated, will run close to $10,800,000, thus establishing a new high record. The company is beginning to receive benefits resulting from the higher prices for its products. This, together with the fact that it has purchased no copper as yet above twenty cents a pound, has materially strengthened the company's position from the standpoint of income. Earnings of $10,800,000 mean nearly twenty per cent on the stock for the current fiscal year.

Boston:	*Closing.*
American Telephone and Telegraph	129
Edison Electric Illuminating	225
Massachusetts Electric	69
New England Telephone	120
Western Telephone and Telegraph preferred	77

The Massachusetts Electric companies report for the quarter ended December 31 last: gross earnings, $1,714,619; operating expenses, $1,228,807; net earnings, $485,812; charges and taxes, $410,291, leaving a surplus of $75,520, as compared with a surplus of $86,298 for the corresponding period of the previous year.

Subscription lists for $40,000,000 American Telephone and Telegraph Company's convertible four per cent gold bonds, due March 1, 1936, were opened on February 5 at 10 A. M., at the offices of J. P. Morgan & Company and Kuhn, Loeb & Company, of New York, and Kidder, Peabody & Company, of Boston. A simultaneous issue of the bonds was made by Baring Bros. & Company, Limited, and J. P. Morgan & Company, in London, and Hope & Company in Amsterdam. These bonds are part of an issue of $150,000,000, all or part of which are redeemable at the option of the company at 105 and accrued interest on or before March 1, 1914, upon twelve weeks' notice. Interest is payable March 1 and September 1 in New York bonds for $10, par value, of stock.

Philadelphia:	*Closing.*
Electric Company of America	10⅜
Electric Storage Battery common	63
Electric Storage Battery preferred	63
Philadelphia Electric	7⅞
Philadelphia Rapid Transit	20¼
United Gas Improvement	91¾

The annual meeting of the stockholders of the Electric Company of America will be held April 23. Following this meeting a special meeting will be held at 1 P. M. for the purpose of authorizing a decrease in the capital stock of the company, to carry out the agreement to exchange Electric Company of America stock for bonds of the American Gas and Electric Company on the basis of $14 in bonds for 10, par value, of stock.

Chicago:	*Closing.*
Chicago Telephone	116
Chicago Edison Light	141
Metropolitan Elevated preferred	70
National Carbon common	81
National Carbon preferred	116
Union Traction common	—
Union Traction preferred	—

The Metropolitan Elevated, to January, carried 150,165 passengers daily, an increase of 20,445 per day or 15 per cent.

The Chicago & Oak Park Elevated daily average of passengers carried during January, including transfers, was 48,494, an increase of 573.

INDUSTRIAL ITEMS.

PASS & SEYMOUR, INCORPORATED, Solvay, N. Y., is sending out some attractive advertising literature calling attention to its specialties. The company's literature will be sent to any one interested upon request.

MACHADO & ROLLER, 203 Broadway, New York city, announces some new literature descriptive of the Hartmann & Braun resonance apparatus for the precision measurement of frequency, speed, etc. This bulletin has been carefully prepared, and in addition to the descriptive matter a number of illustrations are given. The bulletin will be sent to any one interested upon request.

THE STANDARD ELECTRICAL MANUFACTURING COMPANY, Niles, Ohio, has ready for distribution a handsome catalogue entitled, "A Light Suggestion." This calls attention to the several types of incandescent lamps manufactured by the company, and, in addition to the suggestions concerning prices and methods of packing, the booklet is supplemented by considerable data devoted to the characteristics of each type of lamp.

THE CROUSE-HINDS COMPANY, Syracuse, N. Y., has published an elaborate catalogue entitled "Just a Few Condulet Suggestions." This gives a number of very valuable suggestions with regard to wiring and the use of the different types of condulets manufactured by the Crouse-Hinds Company. It would seem that all the possible uses of the condulet were illustrated in this catalogue, but the company states that there are innumerable other ways in which these devices may be used. This catalogue will be sent to any one interested upon request.

THE BENJAMIN ELECTRIC MANUFACTURING COMPANY, Chicago, Ill., has placed on the market a new device designated as the "Wizard" attachment plug. This device renders rotating and twisting of the cord for either insertion or removal unnecessary. A sharp thrust with a slight rotation to the left allows the corrugations to match the threads in the socket shell. A slight rotation to the right insures contact. The plug is disengaged and detached with the pressure of three finger tips. There is no rotation—the parts merely compressed and the plug withdrawn.

W. S. BARSTOW & COMPANY, New York city, in order to meet the demands of its extending business, has recently enlarged its power department. Perry West is at the head of this department. Mr. West graduated from the State College of Kentucky, Lexington, with the degree of M. E., and has been associated in responsible positions with a number of large undertakings. Associated with Mr. West is Carl F. Schreiber, a graduate in M. E. of Columbia University. Another addition to the staff is Rulof Klein, who is a graduate of the Delft Technical University, Holland, and who has been particularly active in gas engineering. A commercial department has also been established, and has been placed in charge of G. H. Noble. Mr. Noble for the past six years was a salesman in the New York office of the Stanley-G. I. Electric Manufacturing Company.

Directory of Electrical and Allied Engineering and Scientific Societies.

(Published in the Second Issue of Each Month.)

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. Secretary, L. O. Howard, Cosmos Club, Washington, D. C.

AMERICAN ELECTRO-THERAPEUTIC ASSOCIATION. Secretary, Dr. C. E. Skinner, New Haven, Ct.

AMERICAN ELECTROCHEMICAL SOCIETY. Secretary, S. S. Sadtler, 39 South Tenth street, Philadelphia.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Secretary, Ralph W. Pope, 95 Liberty street, New York city. Meetings, fourth Friday of each month.

AMERICAN MATHEMATICAL SOCIETY. Secretary, F. N. Cole, 50 West 116th street, New York city.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION. Secretary, J. W. Taylor, Old Colony Building, Chicago, Ill.

AMERICAN ROENTGEN RAY SOCIETY. Secretary, Dr. G. C. Johnston, 514 Bijou Building, Pittsburg, Pa.

AMERICAN SOCIETY FOR TESTING MATERIALS. Secretary, Professor Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Secretary, Calvin W. Rice, 12 West Thirty-first street, New York city.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS. Secretary, G. W. Tillson, Municipal Building, Brooklyn, N. Y.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION. Secretary, B. V. Swenson, 60 Wall street, New York city.

AMERICAN STREET AND INTERURBAN RAILWAY ENGINEERING ASSOCIATION. Secretary, S. W. Mower, London, Canada.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES. Secretary, Ernest H. Davis, Williamsport, Pa.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS. Secretary, P. W. Drew, Milwaukee, Wis. Annual meeting, Atlantic City, N. J., June 19, 1907.

ASSOCIATION OF ELECTRIC LIGHTING ENGINEERS OF NEW ENGLAND. Secretary, Welles E. Holmes, 308 Washington street, Newton, Mass. Annual meeting held in Boston on third Wednesday in March.

CALIFORNIA INDEPENDENT TELEPHONE ASSOCIATION. Secretary, P. T. Whittier, Spencer, Cal.

CANADIAN ELECTRICAL ASSOCIATION, Secretary, T. S. Young, Toronto, Canada.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION. Secretary, J. F. Dostal, Denver, Col.

CONNECTICUT STATE STREET RAILWAY ASSOCIATION. Secretary, E. W. Poole, Bridgeport, Ct.

ENGINE BUILDERS' ASSOCIATION OF THE UNITED STATES. Secretary, J. I. Lyle, 39 Cortlandt street, New York city.

ELECTRIC CLUB OF CLEVELAND. Secretary, George L. Crosby, 1200 Schofield Building, Cleveland, Ohio.

ELECTRICAL CONTRACTORS' ASSOCIATION OF NEW YORK STATE. Secretary, John P. Faure, 77 Water street, Ossining, N. Y.

ELECTRICAL CONTRACTORS' ASSOCIATION OF STATE OF MISSOURI. Secretary, Charles J. Sutter, 1220 Pine street, St. Louis, Mo.

ELECTRICAL TRADES ASSOCIATION OF CHICAGO. Secretary, Frederick P. Vose, Marquette Building, Chicago.

ELECTRICAL TRADES ASSOCIATION OF PHILADELPHIA. Secretary, E. A. Symmes, 810 Drexel Building, Philadelphia, Pa. Meetings, second and fourth Thursdays each month.

ELECTRICAL TRADES ASSOCIATION OF CANADA. Secretary, William R. Stavely, Royal Insurance Building, Montreal, Canada.

ELECTRICAL TRADES ASSOCIATION OF THE PACIFIC COAST. Secretary, Albert H. Elliott, Claus Spreckles Building, San Francisco, Cal. Monthly meetings, San Francisco, first Thursday of each month.

ELECTRICAL TRADES SOCIETY OF NEW YORK (Member National Electrical Trades Association). Secretary, Franz Neilson. 80 Wall street, New York city. Board of directors meets second Friday of each month.

EMPIRE STATE GAS AND ELECTRICAL ASSOCIATION. Secretary, Rolland A. Davidson, 58 William street, New York city.

ILLINOIS STATE ELECTRICAL ASSOCIATION. Secretary, H. E. Chubbuck, La Salle, Ill.

ILLUMINATING ENGINEERING SOCIETY. Secretary, Van Rensselaer Lansingh, Engineering Societies Building, 33 West Thirty-ninth street, New York city.

INDEPENDENT TELEPHONE ASSOCIATION OF SOUTHERN INDIANA. Secretary, E. W. Landgrebe, Huntingburg, Ind.

INDIANA ELECTRIC RAILWAY ASSOCIATION. Secretary, P. H. White, Indianapolis, Ind. Monthly meetings, second Tuesday of each month.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS. Secretary, Frank P. Foster, Corning, N. Y. Next meeting, Norfolk, Va.

INTERNATIONAL INDEPENDENT TELEPHONE ASSOCIATION. Secretary, A. L. Tetu, Nashville, Tenn.; assistant secretary, J. A. Harney, Electric Building, Cleveland, Ohio.

IOWA ELECTRICAL ASSOCIATION. Secretary, L. B. Spinney, Iowa State College, Ames, Iowa.

IOWA STREET AND INTERURBAN RAILWAY ASSOCIATION. Secretary, L. D. Mathes, Dubuque, Iowa.

IOWA TELEPHONE ASSOCIATION. Secretary, C. C. Deering, Boone, Iowa.

KANSAS GAS, WATER AND ELECTRIC LIGHT ASSOCIATION. Secretary, James D. Nicholson, Newton, Kan. Next meeting, Topeka, Kan., October 16, 1907.

KENTUCKY INDEPENDENT TELEPHONE ASSOCIATION. Secretary, J. W. Chambers, Winchester, Ky.

MAINE STREET RAILWAY ASSOCIATION. Secretary, E. A. Newman, 471 Congress street, Portland, Me.

MASSACHUSETTS STREET RAILWAY ASSOCIATION. Secretary, Charles S. Clark, 70 Kilby street, Boston, Mass. Meets second Wednesday of each month, except July and August.

MASTER CAR BUILDERS' ASSOCIATION. Secretary, J. W. Taylor, 390 Old Colony Building, Chicago, Ill.

MICHIGAN ELECTRIC ASSOCIATION. Secretary, A. C. Marshall, Port Huron, Mich.

MISSOURI INDEPENDENT TELEPHONE ASSOCIATION. Secretary, James F. Barnett.

NATIONAL ARM, PIN AND BRACKET ASSOCIATION. Secretary, J. B. Magers, Madison, Ind.

NATIONAL ELECTRICAL TRADES ASSOCIATION. Secretary, Fred P. Vose, 1343 Marquette Building, Chicago.

NATIONAL ELECTRICAL CONTRACTORS' ASSOCIATION OF THE UNITED STATES. Secretary, W. H. Morton, 94 Genesee street, Utica, N. Y. Next meeting, New York city, July 17, 1907.

NATIONAL ELECTRIC LIGHT ASSOCIATION. Secretary, W. C. L. Eglin, Engineering Societies Building, 33 West Thirty-ninth street, New York city.

NEW ENGLAND ELECTRICAL TRADES ASSOCIATION. Secretary, Alton F. Tupper, 84 State street, Boston, Mass.

NEW YORK ELECTRICAL SOCIETY. Secretary, G. H. Guy, 114 Liberty street, New York city.

NEW YORK STATE INDEPENDENT TELEPHONE ASSOCIATION. Secretary, R. Max Eaton, Niagara Falls, N. Y.

NORTHWESTERN ELECTRICAL ASSOCIATION. Secretary, R. U. Kimball, Kenosha, Wis. Next annual meeting, Milwaukee, Wis.

OHIO ELECTRIC LIGHT ASSOCIATION. Secretary, D. L. Gaskill, Greenville, Ohio. Next annual meeting, Toledo, August 20, 21 and 22.

OHIO INDEPENDENT TELEPHONE ASSOCIATION. Secretary, Ralph Reamer, Portsmouth, Ohio.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS. Secretary, F. W. Bullard, Cleveland, Ohio.

OHIO STREET RAILWAY ASSOCIATION. Secretary, Charles Currie, Akron, Ohio.

OLD TIME TELEGRAPHERS AND HISTORICAL ASSOCIATION. Secretary, John Brant, 195 Broadway, New York city.

ORDER OF THE REJUVENATED SONS OF JOVE. C. B. Roulet, Mercury, Dallas, Tex.

PACIFIC COAST ELECTRICAL TRANSMISSION ASSOCIATION. Secretary, Samuel G. Reed, Portland, Ore.

PENNSYLVANIA STATE INDEPENDENT TELEPHONE ASSOCIATION. Secretary, H. E. Bradley, 135 South Second street, Philadelphia, Pa.

PENNSYLVANIA STATE STREET RAILWAY ASSOCIATION. Secretary, Charles H. Smith, Lebanon, Pa.

PIKE'S PEAK POLYTECHNIC SOCIETY. Secretary, E. A. Sawyer, Colorado Springs, Col. Meetings, second Saturday of each month.

RAILWAY SIGNAL ASSOCIATION. Secretary, C. C. Rosenberg, Bethlehem, Pa. Annual meeting, Milwaukee, Wis., October 14, 1907.

RAILWAY TELEGRAPH SUPERINTENDENTS' ASSOCIATION. Secretary, P. W. Drew, Wisconsin Central Railway, Milwaukee, Wis. Annual meeting, Atlantic City, N. J., June 19-20.

SOUTHWESTERN GAS, ELECTRIC AND STREET RAILWAY ASSOCIATION. Secretary, T. H. Stuart, Waco, Tex.

UNDERWRITERS' NATIONAL ELECTRIC ASSOCIATION. Secretary Electrical Committee, C. M. Goddard, 55 Kilby street, Boston, Mass.

VERMONT AND NEW HAMPSHIRE INDEPENDENT TELEPHONE ASSOCIATION. Secretary, G. W. Buzzell, St. Johnsbury, Vt.

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VIRGINIA STATE INDEPENDENT TELEPHONE ASSOCIATION. Secretary, B. L. Fisher, Rocky Mount, Va.

WESTERN ASSOCIATION OF ELECTRICAL INSPECTORS. Secretary, W. S. Boyd, Chicago.

WESTERN SOCIETY OF ENGINEERS (Electrical Section). Secretary, J. H. Warder, 1737 Monadnock Block, Chicago, Ill.

DATES AHEAD.

Underwriters' National Electric Association. Annual meeting Electrical Committee, New York city, March 27-28.

Jamestown Ter-Centennial Exposition. Norfolk, Va., April 26 to November 30.

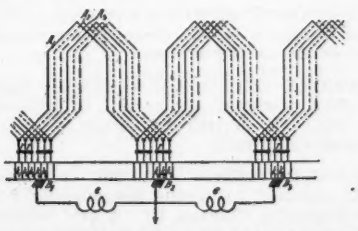
Railway Telegraph Superintendents' Association. Annual meeting, Atlantic City, N. J., June 19-20.

Record of Electrical Patents.

Week of January 29.

842,163. COMMUTATION OF CURRENTS IN ARMATURES OF DYNAMOS. Engelbert Arnold, Karlsruhe, Germany, and Jens L. la Cour, Edinburgh, Scotland. A number of parallel armature sections are connected by resistances.

842,178. TELEPHONE TRUNKING SYSTEM. William W. Dean, Chicago, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill. The trunking connections are controlled by a series of relays.



842,163.—COMMUTATION OF CURRENTS IN ARMATURES OF DYNAMOS.

842,200. MAGNETO. Herman Hess, Indianapolis, Ind. The magnetic parts are held in a non-magnetic body.

842,222. CATENARY SUSPENSION FOR TROLLEY WIRES. George A. Mead, Mansfield, Ohio. Insulators, supported on an angular braced bracket, carry the messenger wire.

842,241. MECHANICAL EAR FOR TROLLEY WIRES. Thomas E. R. Phillips, London, England. Two clamps are pivoted from the ends of a pivoted suspension bar.

842,254. PROCESS FOR THE ELECTROLYTIC REFINING OF METALS. Alfred Schwarz, New York, N. Y. The concentrates are compressed into cake, placed in insoluble frames and electrolyzed.

842,256. ELECTROLYTIC CELL. George O. Seward and Franz von Kügelgen, Holcombs Rock, Va. A diaphragm of solid electrolyte is maintained by water-cooled rings.

842,268. DOGGING MECHANISM FOR TIME AND OTHER LOCKS. Warren H. Taylor, Stamford, Ct., assignor to the Yale & Towne Manufacturing Company, Stamford, Ct. The dog is moved by a pair of solenoids.

842,269. DOGGING MECHANISM FOR TIME LOCKS. Warren H. Taylor, Stamford, Ct., assignor to the Yale & Towne Manufacturing Company, Stamford, Ct. An electromagnet throws the dog.

842,273. PROCESS OF REDUCING COMPOUNDS. Frank J. Tone, Niagara Falls, N. Y. The compounds of silicon are mixed with a reducing agent and a flux and heated in a resistance furnace.

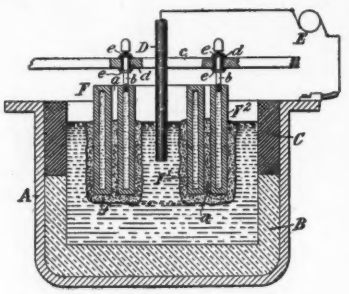
842,285. BLOCK-SIGNALING SYSTEM FOR RAILWAYS. Adoniram J. Wilson, Westfield, N. J., assignor to the Hall Signal Company. The signals are actuated by the train bridging the rails.

842,294. SAFETY STOP FOR ELEVATORS. Herbert Y. Baldwin, Seymour, Ct. The brake is applied by a weight released by an electromagnet.

842,306. TELEPHONE SYSTEM. Francis W. Dunbar, Chicago, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill. A relay, having two differentially wound coils, is connected in the line circuit.

842,315. SINGLE-TRACK SIGNALING SYSTEM. Robert J. Hewett, Westfield, N. J., assignor to the Hall Signal Company. Two signals are provided, one normally held at danger and the other at safety.

842,339. APPARATUS FOR ELECTRICALLY INDICATING WEIGHT. Charles Russo, London, England, assignor to Marconi's Wireless Telegraph Company, Limited, London, England. The relative motion of two solenoids on the weighing device actuates an indicating instrument by means of the alternating current generated.



842,256.—ELECTROLYTIC CELL.

842,342. ELECTRIC CONTROLLER. Harry Sawyer, Muskegon, Mich. The controller is enclosed in a case.

842,358. WIRELESS BALANCE FOR ELECTRIC GENERATORS. Robert C. Taylor and Edward Taylor, Brooklyn, N. Y., assignors to Westinghouse Air-Brake Company, Pittsburg, Pa. The pump motors are controlled by the difference in air pressure in reservoirs and train pipe.

842,366. ELECTRIC BLOCK-SIGNALING SYSTEM. Adoniram J. Wilson, Westfield, N. J., assignor to the Hall Signal Company. The approach of a car throws the signal to safety when the track is clear.

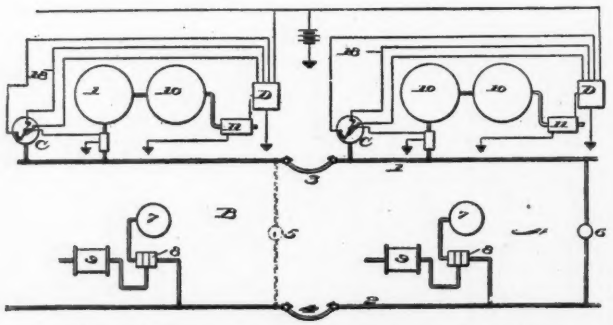
842,367. ELECTRIC BLOCK AND BLOCK-SECTION SIGNALING SYSTEM. Adoniram J. Wilson, Westfield, N. J., assignor to the Hall Signal Company. A differential electromagnetic device enables the signals to be relayed from one section to another.

842,377. SIGNALING APPARATUS. George F. Atwood, East Orange, N. J., assignor to Western Electric Company, Chicago, Ill. A portable telephone signaling set.

842,389. BATTERY. Frank A. Decker, Philadelphia, Pa., assignor, by mesne assignments, to Decker Electrical Manufacturing Company, Wilmington, Del. Conduits connect the various compartments of the battery jar together.

842,410. TELEPHONE SWITCHBOARD. Martin V. Mehren, Genoa, Ill., assignor to Eureka Electric Company, Chicago, Ill. A combined jack and annunciator.

842,413. ELECTROMAGNETIC POWER GENERATOR. Reinhold A. Miller, Indianapolis, Ind. Several armatures are moved successively across the poles of a magnet.



842,358.—WIRELESS BALANCE FOR ELECTRIC GENERATORS.

842,432. ELECTRIC SIGNAL FOR RAILWAYS. Horatio Smelser, Ashton, Neb. The signals are operated by electric motors.

842,514. FURNACE-CHARGING APPARATUS. George Baehr, McKeesport, Pa., assignor to National Tube Company, Pittsburg, Pa. A reciprocating mechanism driven by a reversible motor.

842,515. ELECTRIC MOTOR SYSTEM. George Baehr, McKeesport, Pa., assignor to National Tube Company, Pittsburg, Pa. A controller for a reversible series motor.

842,545. ELECTRICAL CONNECTION FOR RAILWAY RAILS. Eugene Hayward, Clayton, Mich., assignor of one-third to John T. Lueder and one-third to John B. Morris, Chicago, Ill. A bond placed in apertures cut in the end of the rail.

842,571. INSULATION FOR COMMUTATORS. Max Meirowsky, Cologne-Ehrenfeld, Germany. The insulating laminæ are formed of calcined mica.

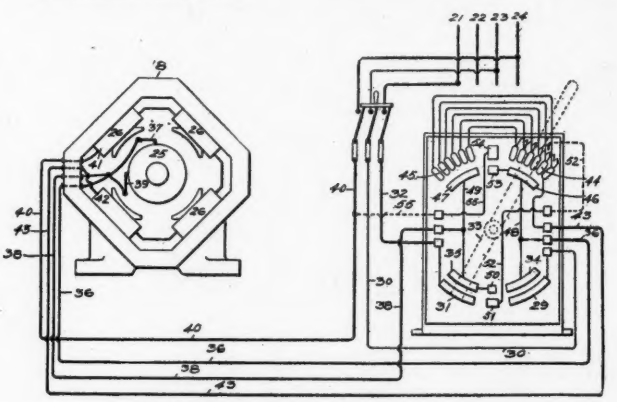
842,574. ELECTRIC DANGER SIGNAL. Alexander McCahon, St. Joseph, Mo. A number of circuits supported on a bracket attached to the rail provide means for actuating the signals on the car.

842,616. BATTERY JAR OR CELL. Joseph Y. Bradbury, Somerville, Mass. A jar of fragile non-metallic material, protected by a jacket of fibre.

842,624. COMMUTATOR. Allen F. Carver and James N. Stout, New York, N. Y., assignors to American Inventions Company, New York, N. Y. Plungers fitted to the yielding contact-pieces are reciprocated by a cam.

842,627. STARTING MEANS FOR INTERNAL-COMBUSTION ENGINES. Clyde J. Coleman, Rockaway, N. J., assignor to Conrad Hubert, New York, N. Y. Starting is effected by means of a small motor and a battery.

842,673. ELECTRICAL APPARATUS FOR SETTING THE POINTS AND SIGNALS ON RAILWAYS. Lorenz Kottmair and Rüdolf Zwack, Munich, Germany. The switch-actuating mechanism is controlled electrically.



842,515.—ELECTRIC MOTOR SYSTEM.

842,730. METHOD OF MAKING ELECTRICALLY CONDUCTING BODIES FOR USE AS CONTACTS. Hermann Viertel, Charlottenburg, and Georg Egly, Lichtenberg, near Berlin, Germany, assignors to Gebrüder Siemens & Compagnie, Charlottenburg, near Berlin, Germany. Metallic powders and carbon are mixed, pressed together and heated until alloying takes place.

842,738. FUSE MOUNT. Charles E. White, Chicago, Ill., assignor to Frank B. Cook, Chicago, Ill. Spring clips for holding a tubular fuse.

842,740. TROLLEY. Pearl J. Wires, Osborn, Ohio. A double-pole trolley.

842,771. BATTERY BINDING-POST ATTACHMENT. George H. Cove, Roxbury, Mass., assignor of one-half to Frank R. Kimball, Boston, Mass. A spring-clip binding-post.

842,772. PARTY-LINE TELEPHONE SYSTEM. William W. Dean, Elyria, Ohio, assignor to the Dean Electric Company, Elyria, Ohio. A harmonic calling system.

842,778. TELEPHONE EXCHANGE SYSTEM. Benjamin O. Fox, Milwaukee, Wis., assignor of one-half to Michael S. Sheridan, Milwaukee, Wis. The desired connection is made by a pawl and rachet actuated electrically.

842,801. STORAGE-BATTERY PLATE. William Morrison, Chicago, Ill., assignor, by mesne assignments, to Exmoor Storage Battery Company, Chicago, Ill. A grid consisting of a phosphorous alloy containing lead and antimony.

842,822. TELEPHONE SYSTEM. Herschel R. Turner, Hoxie, Kan. A party-line system and means for selective connections.

842,829. PROCESS OF MAKING COMMUTATORS. Thomas Duncan, La Fayette, Ind., assignor to Duncan Electric Manufacturing Company, La Fayette, Ind. The segments are formed by depositing a precious metal on a base metal.

842,843. SAFETY ELECTRIC SWITCH. Arthur H. Williamson, Lachine, Quebec, Canada. An enclosed switch.